THE PRACTICAL MAGAZINE

NEW SERIES.—No. 35. VOL. 7, 1877.

SIR HENRY COLE, C.B.

SIR HENRY COLE, C.B.

THE South Kensington Museum is the latest and most distinguished evidence of the public service which a single individual can render to the state when he is not only endowed with but employs to the utmost, the power entrusted to him. Sir Henry Cole is known to this generation principally by his connection with that vast organization; but that really amounts only to an inevitable climax in a life of intense energy and thoroughly practical wisdom. The thirty years preceding that service were devoted to the public instruction in a variety of ways, and his service ever had an originality and perspicacity illustrative of genius in matters of administration, and skill in the choice of means, methods, and management.

In the year 1823 at the age of 15 he obtained an appointment as assistant in the Record Office and continued therein until 1835; the Record Commission itself expired at the death of William IV. and has not been renewed. During that time he pursued a vigorous policy of reforming or attempting to reform the entire management which had drifted into a very bad condition under Mr. Cooper, the secretary. As that is now a forgotten and unpleasant controversy it need not be revived. Mr. Cole's conduct brought him distinction and profit in other fields before even the Record Commission closed. Some eight or nine years later he edited under authority a valuable selection of Historical Records in English History during the thirteenth and fourteenth centuries, and also three or four other works of later date, derived from the researches made during his official connection with the office or with the commission.

Liberated from that duty Mr. Cole commenced the exercise of a versatility for which he is now so famous. His writings in the quarterlies and in newspapers had all the impress of novelty, and conveyed instruction by other than the ordinarily accepted methods.

One of the best educational works that have ever appeared on Drawing for Young Children was published about the year 1835 by Mr. Charles Knight, and Mr. Cole deemed very justly that a supplementary little book on light shade and colour, would make the original book more perfect. Both are scarce now, but when they can be obtained the purchaser is fortunate if he gets them at prime cost. The Education Board have used the ideas on their large sheets for classes. Up to this time, 1840, Mr. Cole had not exhibited an impassioned taste for colour and the artistic arrangement of works of Art, but these first exercises proved him to be well qualified to assist in the great work of diffusing a public and general appreciation of productions hitherto accounted inaccessible to the mass of the population. These exercises refer to,—Effects, Warm and Cold,—Colour and Light, their effects under varying conditions,—the phenomena of Colour and Shade and Shadow. To elicit and to communicate knowledge concerning these he has 500 questions, which, if the student will resolutely master, must make him powerful in the art of drawing in colour and in shade.

Other minor publications followed, but the most important were those on the National Gallery, Hampton Court and Westminster Abbey. The first of these contains representations that "though scarcely measureable in square inches have been pronounced to be really excellent works of art." "I could show," he writes, "that they have the way for giving to the art of wood engraving, a character almost new." In this he had the counsel and co-operation of Sir A. Calcott, W. Mulready, Dawson Turner, and the elder Westmacott. This work, small as it is, created a sensation that, in connection with the others as auxiliaries, led to his distinguished appointment at South Kensington. The good taste in which he spoke of deficiencies and pointed to remedies, and the tabulating of the returns of visitors for the purpose of proving the public interest in art, especially in that of the painters, and the triviality of the cost as compared with the result, pointed him out as a future manager to any national undertaking: valuable succinct biographies of several celebrated artists are appended. In this place we can note the tendency to defend what is unmanneredly attacked, and to do so "with plainness of speech." He had issued this guide book at three prices,—sixpence, threepence, and one penny; and it was a public service, for the price at the gallery had hitherto been a shilling. Within a very few days, there appeared in the trade three rivals having different imprints, but with the same three prices, and these brought out apparently under the auspices of Mr. Hume, the well-known advocate of cheap government; and Mr. Hume did come out of the controversy with flying colours. Making use of his position in the House of Commons that member claimed credit for a public service, which was in fact a public and flagrant plagiarism as unnecessary as it was inferior, and calculated to inflict wanton damage on a venture made with the best motives. He claimed an injunction against Mr. Hume's Society and got it, and actions were entered against the other parties to the fraud. The work was a praiseworthy attempt to re-introduce the Albert Durer style, which it succeeded in doing.

To this useful book he added "A Hand-book for the Architecture, Scripture Tombs, and Decorations of Westminster Abbey," with fifty-six embellishments on wood, engraved by Ladies, and four etchings by David Coxjun. There is nothing especially remarkable in its composition. The artists did their work well, and the author contents himself with bare description. The chapter on Henry VII. Chapel is original, instructive, having a detailed note of every specimen of the architectural sculpture and several Indexes.

He became one of the most active of the spirits that made the Great Exhibition of 1861 a success; in its early stages he drew up documents at the request of Prince Albert in 1849 to prove that the plans adopted should be international, by obtaining from the chief manufacturers throughout the country their opinions and reasons. The idea itself was a French one. M. Buffett after the revolution of 1848 submitted such a proposal to the Chambers of Commerce requesting their opinion on the abstract principle of exhibiting the productions of other countries, and what articles would be best in the French interest to have displayed. But they adhered to protection. English priced calicoes at fourpence and fivepence a yard, and best French customers inspecting British porcelain, Birmingham Electroplate, and Sheffield cutlery, was an idea not at all in harmony with their views of prudence. They would not mind the inspection, but they refused to buy or to awaken inquiry. Some years after, the French Treaty came into force, and this ugly blot has been done away. England, therefore, set the example by inviting the foreign products to be sent here, and the result gave an impetus to art, as applied to manufacture, that has not ceased its influence. This was all the braver, for as one said, "it is most desirable to see the best metal work of all nations, but England will be behind in the ornamental descriptions, especially in those designs that include the human figure."

Mr. Cole happened to be one of the most active in the carrying out of details belonging to Rowland Hill's penny postage. He took a prize of £100 offered by the Treasury for that object, and seeing his opportunity he agitated the question of international postage on that basis. The foreigners who came to the Exhibition joined him eagerly, and formed a society that soon overcame all difficulties, and the penny postage system became practically universal, or at least, a penny for each country traversed. That was one of the results of the Great Exhibition, and that is specially attributable to Mr. Cole.

Much of the credit due to the commissioners for having obtained from the crown an amendment of the Patent Laws is due to the labours of this distinguished individual. Exhibitors declined to exhibit unless a cheap protection against robbery was secured, and the law was hurried through. None too soon did they come; a thousand applications is a great number, but that number does not cover the total.

There is much grace in the literary style of Mr. Cole, and it is remarkably manifest in his famous lecture on the International Results of the Great Exhibition, and in the editorial work connected with that rare book, *The Journal of Design*. Speaking of the contents of the building in Hyde Park, he says, "I feel sure that as each object was mentioned, except a solitary instance, some one would be able to say, "I was acquainted with that object before. That solitary one was the building itself. It has taught the world how to roof in great places, how to build with glass and iron in a way never before done. This is another instance of the logical mode in which supply meets demand, in which invention is shown to be the child of necessity. The only material thing absolutely necessary for an International Exhibition was an adequate building that should be erected in six months . . . . It was obtained; there was nothing novel in iron columns resting on concrete, nor was anything novel in Paxton Girders, which half-a-dozen persons claim to have invented; but there was something very novel indeed in covering twenty acres with glass as an exhibition room such as the world had never seen before. I look upon this building as one of great importance in its way, calculated to have vast beneficial influences on the occupations, health, and amusement of all northern nations." With the like grace he treats of the reward to exhibitors, of the various contents and the consequent national jealousies, and cultivates a generous spirit in regard of rival interests. He thought it might be that other nations are advancing more readily than ours in education and art . . . but "I suspect this education turns to little account, for when

they become men, they are then free to write and read what they please; I do not question the value of science; but science appears to me only one of many ingredients necessary for the prosecution of successful industry." In such bold ways did he recite confirming facts, gleaned from history, that should encourage English industry and English trade to whatsoever rivalry they might be exposed.

But one of the chief "aids to inspiration" concerning the project of the International Display in Hyde Park was the establishment in 1849 of *The Journal of Design*, which was not then sufficiently appreciated, nor ever will be. Schools for Design at that date were in a crude form, and open to many abuses in themselves and unprotected when able to yield profitable results. He established this Journal "that the manufacturers and students of design might find something like a systematic attempt to establish recognised principles." "In our examinations of woven garment fabrics, chintzes, iron, silver, &c., we have endeavoured to arrive at the principles which ought to govern decorative designs in these materials. By the time of the completion of Vol. III. the new Copyright Amendment Bill had passed the parliament as a consequence of Mr. Cole's able advocacy of the interests of Designers. "It is not often," he writes, "that a Journal may justly quote so positive a triumph of its labours as this Act certainly is."

In Feb. 1852 that Journal ceased. It was instituted to promote the Great Exhibition, to indicate better art principles, to improve copyright registration, and to effect the reform of Schools of Design, the change of the Patent Laws, &c. The triumphant success of the Great Exhibition, the affirmation of principles and its progress of public opinion on Design, and the great improvements connected with Industrial Art, caused indeed the cessation of the Journal. The three years of its existence had brought crowds of friends, Messrs Dryce, Redgrave, John Bell, Owen Jones, Digby Wyatt, G. Wallis, Hornsby, and others. He then says that when he begun in 1849 there were not a hundred manufacturers who were positive advocates of Industrial Art Education, and the "Illustrative Catalogue of the Great Exhibition records the names of thousands of them;" and finally "trusts that his Journal will be found a not unworthy record of the events of the past three years—the most important for Industrial Art in modern times—and that until a better code appears, it may serve as a primer on *the Principles of Practical Art.*"

That is exactly the just description; and now we will proceed to notice the growth of his successful labour and reward.

There are few gentlemen so capable as Sir Henry Cole to advise government in matters connected with the public provisions for disseminating knowledge in art matters, and providing efficient arrangements for exposing objects that afford instruction. A very strong party in the House of Commons hold the South Kensington Museum to be a den of schemers and charlatans, and resist any and every project that comes to them with the endorsement of that gentleman: but we have nothing to do with prejudices: our object is to describe his opinions, and this is not difficult because of the frequency and boldness of his utterances. Here are his opinions:—

Government has a duty towards Education, Science, and Art, which duty is of recent acceptance. Fifty years ago governments knew no duty to Education, Science, and Art, and no votes of money passed the House on such account; but in the year 1875-6 in various ways three millions were expended. The existing political executive is the servant of the commonwealth and not its governor. A cabinet that fails to obey the popular desire is banished from office: if it errs, it must apologise. It is dependent on the general sense and good will, of which it is the trustee and treasurer. Favours cannot emanate from a government; they must administer precisely what the subject demands. Fifty years ago it did not make any demand in educational matters; now its requirements increase every year: and it is no sacrifice of national independence to ask for what is our own. In fact it is precisely what should be done. Politicians now cease to express sympathy with and offer counsel to all those who labour in disseminating art, knowledge, and education. The highest names are repeatedly urging hearers to cultivate science because of its immediate applicability to industry,—he proceeded to advocate the establishment at state charges of local museums, or at least to render them assistance wherever they are set on foot, and thus recognise all such institutions as part of the state duty in educating the people. Sanitary law, domestic economy, physical law, and kindred subjects formerly omitted, are now becoming part of the curriculum in girls' and boys' schools under the support of the Society of Arts, and partially recognised by the Education Department.

The Society of Arts commenced in 1855 the system of Examinations which has since been promoted by government and the Universities until the Society is now supplementary to that of the State, in such actions as giving certificates in Commercial Knowledge, and the like. Again Technology, which applies to manufactures, have been made an examination subject; as also Domestic Economy. Papers are given out at examinations for these, and also on Fine Arts applied to Industry. Sir Henry then urged the adoption of all these subjects into night schools. The laws of Health, Domestic Economy, &c., could be disseminated by that method among a class that are now excluded, and to whom such knowledge would be beneficial. He then urged the direct stimulus of prizes in common schools for culture in Music and Cookery and even Scholarships at State charges. He hoped to see the present principle as to Primary Education being united to the State extended to Secondary Education and Public Museums, and that the latter should legally be open on Sundays.

In connection with this part of our work candour demands us to say that the hostility towards Sir Henry Cole had some warranty. His opponents alleged that all his suggestions tended towards the centralization of all the choicest works that could be collected at South Kensington; and that if such a course were chosen it must impoverish and make less attractive many places that have other associations. This little privately printed tract of six pages about Hampton Court certainly tends to justify the public objection. To denude Hampton Court of the few good works of art, or of its choice Pictures, or the Technical ones, because it is chiefly as a place of popular concourse that its fame is derived, is neither fair or wise. Good works of Art are most impressive in comparative isolation; a good picture can then best tell all its teaching.

Flattering the Crown for having ceded a privilege of inspection that ought never to have been claimed is a very weak proceeding; and recommending that the place be dismantled and the cost of restoration be borne by the State is likely to be treated with something akin to contempt. England never grudges money of that kind, and her sovereign very seldom permits such questions to be raised. Neither party would be justified. And in this case the regret is the deeper in that the author of the suggestion ought not to appear in the guise of a tuft-hunter, nor the Crown which has had the property for nothing be supposed to be lacking in taking due care of the inheritance with which it is entrusted for the public good.

The excellence of Sir Henry Cole is in the very quality for which some have offered him opposition. He is one of the very best organizers in the country. It is evidently a vocation; and such a vocation must inevitably call up antagonists who neither like their ideas set aside, or are willing to form parts of any great scheme. This has, no doubt, alienated some of the highest authorities in art from associating themselves with South Kensington, and compelled the co-operation of many who have small capacity and large self-conceit; but the result is a very great triumph. His handy-work is everywhere seen. His stamp is on every item of management, and the outcome is a magnificent public institution. Being young, there is perhaps a perkiness and love of pre-eminence that are unbecoming, for it needs no advertising or puffing, and its position is unassailable: these defects arise from the very circumstance that the whole has been effected by the instrumentality of one man, and that others have been merely endorsers of his suggestions.

This faculty brought upon him the direction of that most interesting and most fruitful of all exhibitions—the Bethnal Green Branch of the South Kensington Museum. He wrote a brief guide to the Animal Products Collection. The building is a part of the famous—"Brompton Boilers"—iron rooms at South Kensington, which were superseded by the erection of the fine brick structure which now adorns the place, and which will continue to increase for the next ten years. These "boilers" so called from their circular roof, were offered to the authorities in the north, south, and east of London to form a nucleus for such exhibitions, or portions, as might be best adapted to the local claims for special teaching. Sir Antonio Brady on behalf of East London addressed the President of the Council of the Society of Arts, setting forth the claims and position of that district,—that it contained a million of artizan population, that the land belonged to the poor when all was open fields, and that the trustees could be dealt with—that he would guarantee the purchase of what might be required and offer it to the Government for the purpose of erecting a museum there. The Chancellor of Exchequer, Mr. Disraeli, promptly accepted the offer, obtained a grant for building and maintenance, and Mr. Cole assumed the office of director, and the Animal Products Collection, and the Food Collection were removed from South Kensington with the building in which they had previously been stored. Other contributions were added; Economic Entomology, by Mr. Murray; Paintings, by Sir Richard Wallace, and a large Library. Refreshment rooms were also provided, and the whole was opened in

state by the Prince of Wales on behalf of the Queen, 24th June 1872. This was exactly the work that Sir Henry Cole could do, better than any one besides, and the result has in every way been a magnificent success. It is at present the only example of local museums in London, but the north and the south will before long follow the same course.

When the second Exhibition—the International of 1862—was being organized Mr. Cole took a strong position on the subject of the regulations. The Commissioners had laid down the rule that all the arrangement of objects should be taken out of the hands of the exhibitors and be placed in those of an officer or officers they might please to appoint. He contended that the exhibitors were by far the best qualified persons for placing their objects most effectively within the prescribed space allotted them; instancing that much confusion and complaints had arisen from technical blunders by an opposite course in 1851, notably, that in colours—some vegetable, some mineral, some chemical, had been jumbled together under the class, pigments; which could never have occurred had the exhibitors themselves managed their own descriptions and arrangements; and contending that the general experience exhibitors had acquired in Hyde Park in 1851, and in Paris in 1855 still further qualified them for the special work for which a stranger, ever so versatile, could never be qualified in a competent degree. He carried the point.

Another instance of his freedom from trammels occurred on the occasion of the proposal at the Society of Arts' Meeting just after the death of the Prince Consort. A large body, indeed almost all of the members, desired to take the initiative in some undertaking that should perpetually commemorate the name of the best friend that institution ever had. His contention was that their action was premature and inopportune. The nation would doubtless take a parliamentary method, and they —the Society—might after that adopt some humbler project more decidedly identified with their own position, and the relations existing between themselves as a body and the great mind which had been so intimately their guide and friend. That also succeeded. A bust, and a perpetual gold medal are constant reminders of the estimation in which the Prince had been held by the Society in his life-time, and an annual stimulus to those who should emulate the highest honours that body can bestow in their periodical examinations.

We would now notice the many events in which Mr. Cole, or as he became Sir Henry Cole, gave expression to his opinions and how he attempted to direct popular thoughts in the general world.

Mr. Cole's zeal often leads him into expressions that breathe iconoclastic theories, as when in 1868 he attacked Sion College, in London Wall, merely because the readers at the library were few; forgetting, if he knew, the historic associations belonging to the name of the founder, and also despising—if he knew—the fact that Sion College is a neutral ground which has often been of great national service when churchmen and nonconformists disagree, and also when the various parties in the Church filled with differences have sufficient charity to meet together. He wished the land and old buildings sold, and the books offered to the Archbishop of Canterbury for deposit at Lambeth library. London, and all England, has a greater reverence for tradition than it has respect for any modern institution, even if it be so perfect as that at South Kensington. He further desired that Westminster Abbey should empty its stores and follow the lead, and he invited a discussion in the Society of Arts, or the Royal Society, on the subject of a universal theological library to be consecrated property held in trust. The zeal for combination and display led him here beyond what was wise. And again in deriding the appointment of official trustees that are independent of art as guardians of the stores at South Kensington, which is the practice with singular efficiency at the British Museum, he, in the opinion of many who attach the highest value to his services, committed a needless offence that amounted to a blunder; because it is most important in all national establishments, for whatever purpose or object, that the services of those who are known to be efficient administrators should be engaged in the seats of authority in preference to those who are able to boast of technical knowledge, and even traditional connection. The British Museum is already with all its freedom in this respect too much under the dominion of red-tape: the principal librarian arrives at the post by mere seniority, and the result is paralysing. At South Kensington that same tendency is manifest, and needs the check of public surveillance by the agency of independent trustees. Mr. Cole on the one hand is often iconoclastic, and on the other excessively monopolising. Such an institution has a tendency to cliqueism, and that tendency, so injurious, has its chief defender and exemplar in the most worthy gentleman of whom we speak so harshly but not unkindly.

This is not the time to enter much further on a subject that contains great ramifications, and has associations that are entwined in the art-resurrection of our day—and therefore it shall be dismissed with some reference to public work performed by the subject of this notice on the Continent, and indirectly in other places.

On Wednesday, the 15th February 1873, Mr. Cole attended at Nottingham to distribute the prizes to the successful students of the School of Art in that town. Nottingham has the distinction of being the first to establish a local and permanent museum of art, science, and local industry, founded by the aid of its municipality, the voluntary subscriptions of its inhabitants, and a grant from the State; and his observations at that gathering deserve permanent record. The facts he stated are,—that more than twenty years ago Lord Granville asked him to undertake the superintendence of the Schools of Design. He accepted the appointment, and held it under all shades of political parties, serving under Lord Taunton, then Mr. Henry Labouchere; Mr. Henley, who was the first to insist on the artizan population being instructed in geometrical drawing; Mr. Cardwell, who enlarged the Department of Art into Science and Art; Lord Stanley of Alderley, under whose official life the museum was transferred from Marlborough House to South Kensington, then founded by Prince Albert; Lord Granville, under whose administration the permanent buildings at South Kensington were commenced, and who inaugurated the project of Bethnal Green Museum, which was effected by the Duke of Buckingham who caused the new Science Schools to be built; and the Duke of Marlborough who prevailed on Mr. Disraeli's Cabinet to make the most liberal and profitable investments in works of art. Mr. Cole had spent fifty years in the public service, and since 1852 had witnessed the conversion of 20 limp schools of design into 120 flourishing schools of art; 500 night classes for drawing had been established for artizans; 180,000 boys and girls were now learning elementary drawing; 1,250 schools and classes had sprung up spontaneously for science instruction; and the South Kensington Museum had been securely founded as a national centre for consulting the best works of science and art, and the means of circulating art objects through the kingdom, which it had done to 195 localities holding local exhibitions that had been visited by four millions of visitors whose payments reached £93,000. He now had arranged to retire in April, but should ever be an active volunteer in the work he had loved all his life.

The retirement of Mr. Cole took place as arranged, and on Friday, July 11, an influential meeting was held at Willis's Rooms, King St., St. James', to form a provisional committee that should promote a testimonial recognising the public estimate of the personal labour bestowed by him for the general good. Lord Granville, Lord Houghton, the Duke of Sutherland, Mr. George Godwin, Sir Digby Wyatt, and others, advocated the project, and it was brought through in 1874 by a splendid testimonial.

In corroboration of the remarks made a little while back on Mr. Cole's excessive partiality for South Kensington leading him a little beyond the boundary of fair play, we cannot avoid the great meeting at Hanley, Oct. 21, 1873, called for the distribution of prizes to the four Schools of Pottery Art. He recapitulated and enlarged on what he had said at Nottingham three months before, and eulogised South Kensington to the very limits of candour and truth. That would not matter, had he refrained from a most unjustifiable attack upon an institution born before South Kensington and of more profound utility than it. Comparisons seldom can be kept within the fences justice prescribes, and are moreover apt to become offensive. It is not our business here to defend the British Museum so ruthlessly and unjustifiably attacked by Mr. Cole. The trustees covenant to bestow to South Kensington the natural history collection years ago, which is the most attractive to common sight, and ordinary gratitude, should have bidden Mr. Cole restrain a vulgarity of speech that he might think good enough for a Hanley multitude, but which he dared not employ in London. Again his zeal outran his discretion.

Of the manner with which Mr. Cole managed the interests of England at the Paris Exhibition of 1867 the correspondent of the *Times* wrote graphically in reference to a "favoured nation" order about closing that gave French exhibitors an unfair advantage. "If the French Administration had any notion or idea of dealing as they listed with our countrymen, they were much mistaken in any matter wherein Mr. Cole had to manage with M. Le Play. That is a very clever man, but he cannot say of any day in which he was brought into antagonism with Mr. Cole that he was not "*dies carbone notanda*," pregnant with rout and disaster. Surely we ought to be grateful to the man who struck such shrewd blows for St. George and Kensington, and did it with such masterly scope that he had not to call in vile scoldings

and temper to his aid like the Prussian Commissioner, but conquered easily—*stans uno in pede.* Austria admires him, Russia envies him, Prussia imitates but equals him not, and France fears him—the Garibaldi of exhibitions, whom mountains rough or round can neither elevate or depress—*nec vultus instantis Le Plæi.* In sober truth Mr. Cole has had hard times of it, and has conquered them, performing his arduous duties with good-humoured resolution, ability, and success, and giving an *élan* to the British section which put it on its own merits and gained it proper consideration, while he showed an original mind in many details, and no small artistic and inventive power."

Thousands of British workmen were, under Mr. Cole's management, taken over to Paris and instructed in the various departments that contained rival manufactures or machinery, and the Science and Art Department provided £7 each for the expenses of 200 certificated science and 100 art teachers who were in return required to furnish notes as reports of what they saw and what they learned thereby. W. S. C.

MR. LE GRAND ON TUBE WELLS.

AT the meeting of the Society of Engineers, Mr. Le Grand has recently supplied a most interesting paper on the subject of Tube Wells. Times of War and times of Exploration require these excellent examples of science, and he has put in form for the good of practical men what information he had and could acquire. It is now a little over ten years since tube wells were introduced into this country. The first notion came from America, though a contemporary claim has been made from yet another quarter of the globe. The crude idea had lain dormant for nearly two years, and might have done so for many more, had it not come into the hands of Mr. J. L. Norton, whose indomitable energy soon produced the necessary appliances to develop it into an invention of real practical utility, for which three separate patents were taken out. Public trials of its usefulness were made in London, Manchester, and elsewhere, and as Government was at that time preparing its expeditionary force for Abyssinia, the War-office authorities had their attention drawn to the invention, and with unusual alacrity they ordered trials to be made at Chatham. These trials so satisfied the commandant of the Royal Engineers that he forthwith recommended the authorities to adopt tube wells as part of the equipment of the corps of Engineers, and they continue to form an integral part of such equipment to the present day. It is needless here to recall the fact of how valuable they proved in Abyssinia, and how, as a matter of course, they were sent to Ashantee. Incidentally, it may be mentioned, as showing what an interest the late Emperor of the French took in all matters of public utility, no sooner had they become known through the wide-spread publicity given to the invention by the press, than he sent over and invited Mr. Norton to bring his apparatus to St. Cloud. Mr. Norton accordingly repaired thither, and, in the presence of the Emperor and the Prince Imperial, drove a well. The soil proving favourable, it only occupied half an hour to drive 28 ft. deep, and to obtain a good supply of water, both the Emperor and the Prince Imperial assisting in the work. Most inventions of the present day are known by some distinctive name or appellation given to them by their respective proprietors, but this was not the case in this instance, for by a sort of common consent both the press and the public dubbed them "Abyssinian" tube wells, and sometimes "Abyssinian" pumps; the latter can, however, hardly be considered correct, as the invention relates almost exclusively to making wells, while pumps of various patterns are employed in the work, and all descriptions of pumps are applied to them when permanently set up. Before proceeding to describe the invention in detail, it may not be amiss to correct one or two popular errors which have even found their way into the "Government Text Book of Instruction in Military Engineering." One is, that any sort of

FIG. 1

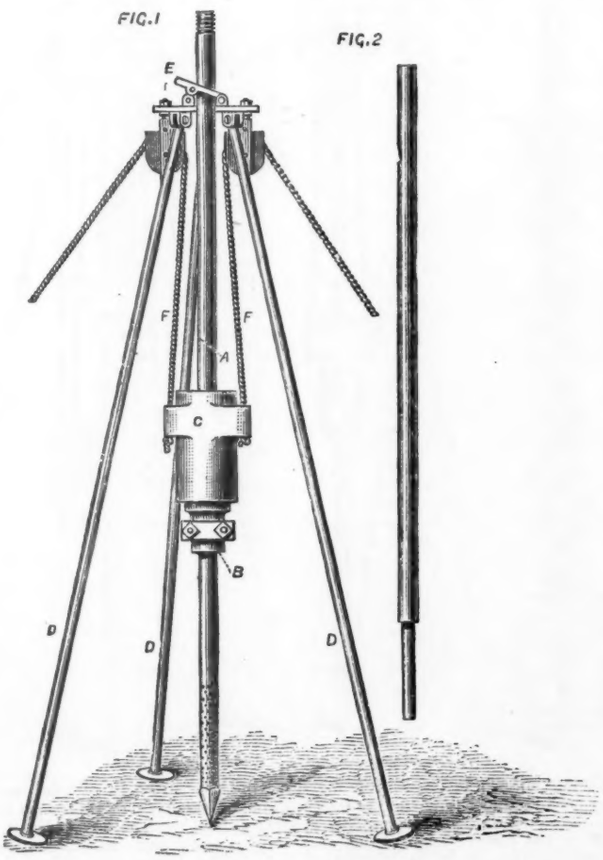
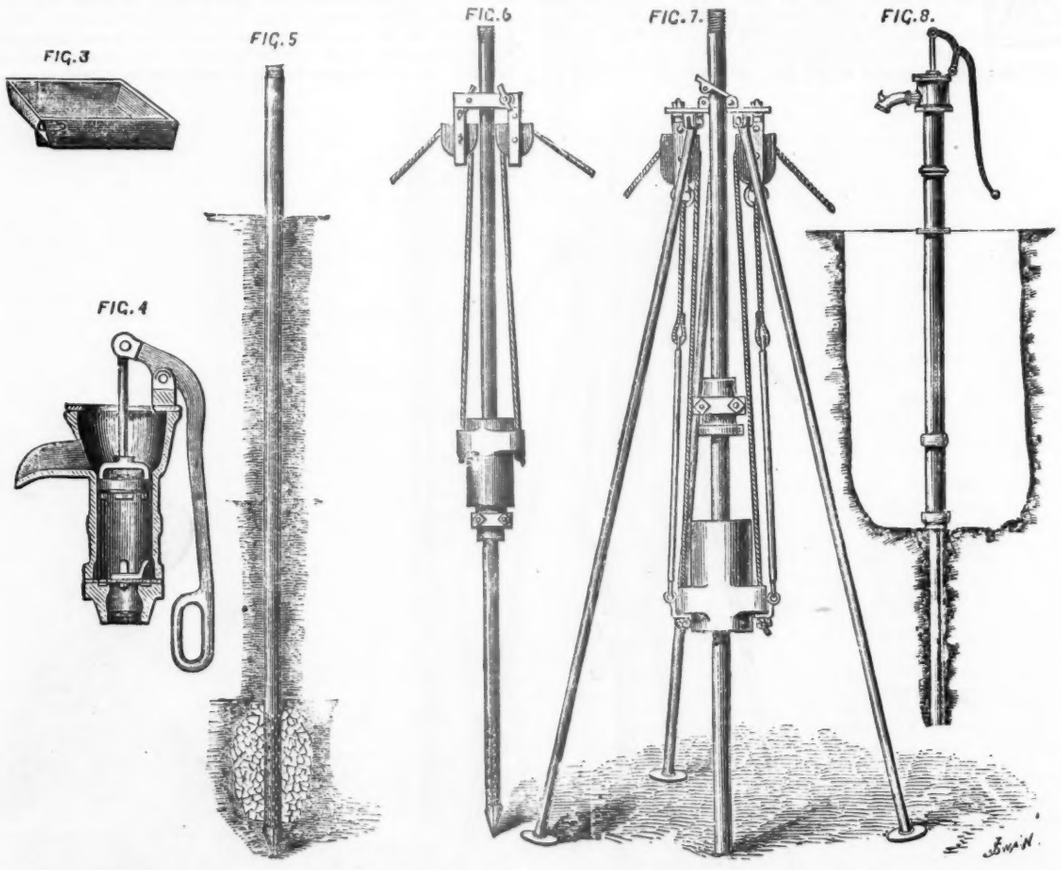


FIG. 2

common gas, or other pipe, will answer the purpose, whereas specially tough lapwelded tubes are required for the work in order to stand the hammering and vibration to which they are subjected; ordinary tubes being found to crack in all directions. Another common mistake is that these tube wells can be of no use beyond 30 ft. Hundreds have been driven to much greater depths, and in nineteen cases out of twenty the water from the springs, when tapped, rises to within reach of a suction pump, occasionally flowing over the surface. Where the water does not rise to within reach of suction, special modifications hereafter described meet the contingency.

The process of driving tube wells resembles pile driving, but with this distinction, that while piles receive the blows of the monkey on their heads, the tubes are not struck at all, the blow being communicated by the clamp, which receives the blow near the ground. The tube well as ordinarily used is not intended for piercing rock or solid stone formations, but it is quite capable of penetrating very hard and compact soils, and can also be successfully driven through chalk, breaking through the flints which may obstruct its passage downwards. When solid masses of rock or stone are reached, special means of drilling have to be provided for it. When coming upon rock or stone the best plan is to pull up the tube and try in another spot. This applies also when deep beds of clay are driven into, for by going a little distance off and testing again in many cases water will be found. The mode of operation is as follows: The first or pioneer tube—as shown in Fig. 1—is furnished with a steel point of bulbous form, and perforated with holes varying from ⅛ in. to ¼ in., extending from 15 in. to 3 ft. upwards from the point. The enlargement of the point serves to clear a passage for the sockets by which the tubes are screwed together. On to this tube the clamp B is fastened by two bolts at about 3ft. from the point; the clamp is of wrought iron, lined with steel, and screwed internally so as to form teeth to grip the tube. Next the cast iron driving weight or monkey, C, is slipped on to the tube above the clamp. The tube thus furnished is stood up perfectly vertical in the centre of the tripod or shearlegs D D D, in which it is retained by the latch E. The feet of the tripod should be looked to in order that they be firmly planted, and do not slip or sink during work. The whole being now arranged in position for work, the ropes F F are made fast to the monkey and passed over the pulleys of the tripod, and driving is commenced by two men pulling the ropes and allowing the monkey to fall on the clamp. At this point particular attention must be paid to frequently tighten both the bolts equally as the driving proceeds, for the clamp must not on any account be allowed to slip, otherwise the blow of the monkey is in a great measure lost, the result being no good to either clamp or tubes, besides wasting time. As soon as the clamp reaches the level of the earth by dint of repeated blows, the monkey should be raised, and, one man taking a turn of his rope round one of the legs of the tripod, holds the monkey suspended while the other loosens the bolts of the clamp and raises it about 18in., and tightens the bolts again as at the commencement. If the ground

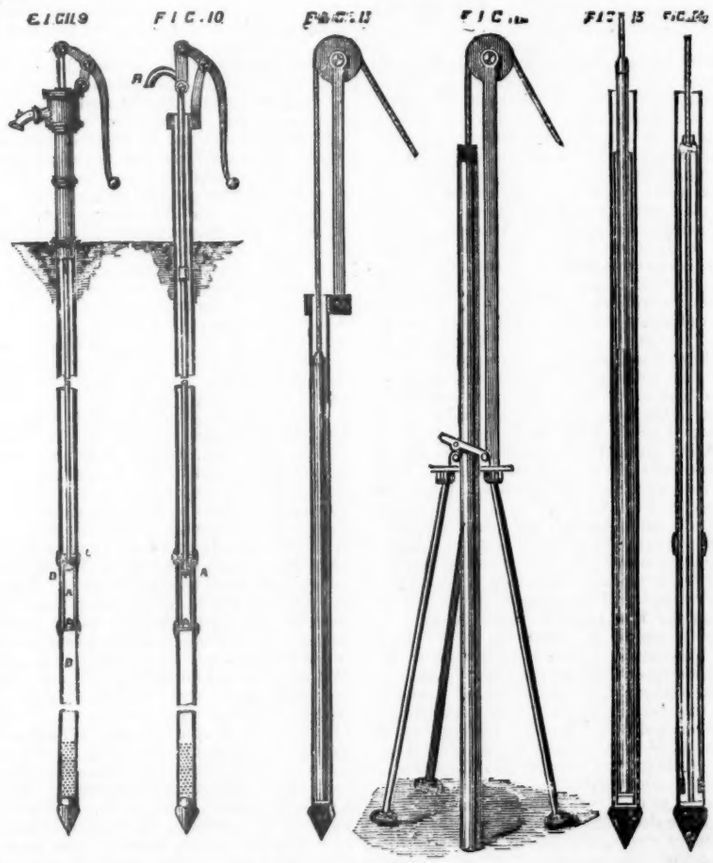


be very soft the clamp can be raised 2ft. or more, as it saves the frequent re-adjustment; if very hard not more than 1ft. In this manner driving is continued until the top of the tube comes below the hole in the tripod head, or top plate. Immediately it reaches this point the lengthening bar (Fig. 2) is brought into requisition by dropping its small end into the top of the well tube. The object of this lengthening bar is to keep the tube steady, and to enable the operator to have a temporary guide for the monkey to slide on, until the well tube has been driven into the ground to within a foot of its entire length. This, as will be readily understood, could not be accomplished by screwing on a fresh length of tube, as the socket joint would not allow the monkey or clamp to pass over it. When driving in hard ground the lengthening bar is apt to rebound, and in so doing it would burr the well tube, but to obviate this a small india-rubber ring or washer formed of twisted string is placed at the shoulder. Before the tube has, however, been driven thus far, a hollow iron plumb is lowered into it, so as to ascertain whether water has been reached, or whether earth of any kind has got into the tube. This indicates what depth of earth or water stands in the tube. If neither are present the iron plumb will strike plainly on the bottom of the tube; should earth be

present, by allowing the plumb to strike on it once or twice, some will adhere to the bottom, and thus indicate the nature of the soil. It should here be mentioned that after the first tube has been driven, the well should be plumbed again as soon as the second tube has been driven, say, 3 ft. or 4ft. into the ground, and every 2 ft. or 3 ft. afterwards, otherwise, by neglecting this, a seam of water may be passed without knowing it. If after more or less driving not more than a few inches of earth, and that of a comparatively dry nature, be found in the tube, no notice need be taken of it; but should it increase to a foot or more it should at once be removed by the aid of the cleaning-out tubes. To connect the fresh tube, the monkey is first suspended in the manner previously explained, and the clamp removed from the tube that has been driven and fastened on to the length of tube about to be added to the well, at about 6in. from the end of the tube which has the socket, the small end of clamp being towards the socket. The tube with the clamp on it is then passed through the suspended monkey and secured in its place in the tripod head, and then screwed as tightly as possible on to the tube that has been driven. In fact, the tubes must meet or butt against each other, and the joint altogether must be made so tight that it cannot unscrew in the course of driving. Length after length is in this manner added until the desired depth is reached.

When earth or clay finds its way into the tube while driving, it is removed by means of small cleaning-out tubes, usually ½in. internal diameter, which are provided in lengths to suit any depth. A sufficient number of these to reach to the earth in the well tube must be screwed together, and each should be carefully lowered into the well tube, all but about 6in., and sustained in this position by tongs, while another length is screwed on to it. Care must be taken in lowering these tubes not to let them slip down, otherwise considerable trouble will be caused in recovering them. When the accumulation in the well tube is of a loose sandy nature, if wet it can best be withdrawn by means of the pump, which, with the reducing socket, can be coupled on to the top of the cleaning-out tubes. When this is the case, before screwing on the pump, the funnel (Fig. 3) should be screwed on the top of the well tube, so that, if necessary, water can be poured down the well tube, when, by pumping, sand and mud will be pumped up, and by continuing to pour fresh water down the tube, and pumping up through the small tubes, all the earth can be removed.

When water is struck, and stands several feet in the tube, the pump (Fig. 4) can be applied. This is furnished with a broad, open top, in order to facilitate the removal of sand, &c., which may accumulate. It requires simply to be screwed on to the tube well with white lead. To start the pump, some water is



poured to prime it, and when the air has been exhausted, in all ordinary cases the water will follow. At first the water pumped will be muddy and gritty to a greater or less extent, according to the nature of the strata. After pumping for a short time, and the water shows signs of clearing, the handle of the pump should be raised high for a second or two; by doing this the bucket will press on to the spur on the clack valve, and cause it to open, and simultaneously the tumbler valve in the bucket will be raised, upon which the water will run suddenly down the tube, which a few strokes of the pump will recover; and this should be repeated several times. The result of this sudden letting down the water several times, and stopping it before it has got down to the water level of the well, causes the water to force its way violently in and out of the perforations at the bottom of the tube well, disturbing the mud and fine particles of the stratum around the perforations. If this has been done properly, the water will again have become muddy and thick, as at first, and steady pumping will, in a short time, bring up all the mud and fine particles which have thus been disturbed. The object of this stirring up of the mud is to thoroughly disintegrate the soil, and clear away all the finer particles in the immediate vicinity of the perforations, leaving the large stones and grit to form a natural filter around the tube well. Fig. 5 shows a tube well that has been driven, and the soil disintegrated around the perforations in the manner described. This process should be repeated several times, until it is found that the mud ceases to come up;

for upon the careful carrying out of this greatly depends the quantity of water which the well will yield, and the ease with which it can be pumped. The neglect of this will, in many soils, cause sand to come up some time after the well has been made, and will diminish the yield, and also the ease of pumping. Moreover, in some strata, if this be not properly done when the well is first made, the sand will accumulate in the tube well, and tend to stop the supply altogether.

When first starting to pump a well in the manner just described, should the sand accumulate so fast as to prevent the pump from raising the water, the cleaning-out tubes must be employed, in order to pump up all the sand clean out of the tube; and when this has been done, the pump can again be screwed on to the tube well, when in most cases it will be able to pump up the rest till the well has been cleared. If at first the water only comes with great difficulty, it must not be concluded that no supply can be got; on the contrary, in nine out of ten cases, by a free use of the tilting action of the pump, the compact earth will be broken up and loosened, so that after half-an-hour, or several hours' pumping, it will produce a perfectly free yield, where at first it was difficult to get half a supply, and a little perseverance will be amply rewarded. Fig. 6 shows the plan adopted by the Royal Engineers, dispensing with shearlegs on account of their weight, and in their place employing simply a pair of pulleys clipped on to the tube itself.

When from any cause it is found necessary to withdraw a well, it may be accomplished by fastening the clamp to the tube a few inches from the ground, and making a fulcrum of the monkey, raising up the tube with the lengthening bar or any available lever, lowering the clamp after each successive lift. Another plan, when the tube is very firmly imbedded, is to put the monkey on the pipe the reverse way to what it is when driving the well, and then fasten the clamp on the tube also the reverse way, about 2 ft. above the monkey. A man on each side pulls up the monkey against the clamp, and this drives it up out of the ground. Fig. 7 shows this; the work, which would otherwise be very laborious, is by a simple contrivance, made quite easy. The whole weight of the monkey is supported by two stout india-rubber springs, similar to those used to close doors. All the workmen need do is to give the momemtum to the monkey by pulling the ropes and cause it to strike upwards against the clamp. When the tubes are withdrawn they may be re-driven in another spot. In withdrawing the tubes each joint must be unscrewed as it is raised to the surface. Before attempting to drive the tubes afresh they should be examined to see that they are perfectly straight. Bent tubes should never be driven, as they are not only apt to bend worse, but if they come on anything very hard they are liable to spring and not drive at all. In cases where the water level is found to be but a few feet below the reach of a suction pump, the simplest plan is to dig down 5 ft. or 6 ft. and take off the top length of tube, and, after having cleaned up the well with the usual pump, a long barrelled pump—as shown in Fig. 8—reaching to the surface is attached to the well tube, and the hole that has been dug is filled up again, as the lower box of the pump can always be got at from the surface at any time it may require seeing to. Where, however, the water level stands some considerable depth below lifting reach, the plan adopted—shown in Fig. 9—is as follows: When the first tube has been driven into the ground, the working barrel, A, consisting of a short length of tube lined with stout brass, together with the conical brass seating, B, is screwed on to the tube which has been driven; next, the washer, C, is placed on the working barrel. This washer is to prevent the brass lining from jarring up out of its place while being driven. To this working barrel are then added fresh lengths of tube, driven in the usual way, until the barrel reaches just below the water level. The Bucket, D, connected with suitable lengths of rods is lowered into the working barrel and attached to the lever in the pump head as shown. In clearing up these deep wells, owing to the comparatively large size of the tubes employed, the up current of the water when pumping is not of sufficient velocity to carry up with it the heavier portions of grit, &c., which, consequently, accumulate in the barrel. To overcome this difficulty a sort of plunger pump of a novel description has been designed—Fig. 10 shows a section. The plunger box, A, is furnished with double cup leathers placed in reversed positions, *i.e.*, one cup downwards and the other upwards; a tumbler valve is fixed at the bottom, the tubular rod which carries the plunger box communicates with it, and when the lever of the pump head is raised, the water, grit, &c., instead of passing slowly up the long well tube is forced rapidly up the small tubular rod, from whence it is expelled at the outlet, B, and by this means all the heavier particles can be effectually cleared out of the tube well.

It may be observed that Mr. Norton's patents passed into the hands of Messrs. Le Grand and Sutcliff, of Magdala Works, Bunhill-row, London, a few years back, and this firm has recently patented an entirely new method of driving tubes applicable for wells, and for other purposes, which the author will now briefly describe. In practice it has been found that when driving in very hard bands of strata, immediately the point has penetrated through them the driving becomes quite easy again, irrespective of the depth that may have been reached. For instance, it is quite common for a tube to take many hours driving through an obstruction of 3ft. or 4ft., met with say at 20ft. or 30ft. below the surface, and subsequently driving at four times the pace when reaching possibly double or treble the depth. From this fact, it is quite evident that the first tube with its point accomplishes the whole work of penetration, leaving the tubes that follow practically no resistance to overcome. Instead, therefore, of striking the tube at or about the surface as in Norton's method, and having to transmit the blow through any length of pipe, varying according to the depth driven, Le Grand and Sutcliff's arrangement delivers the blow immediately above the point at the bottom of the tube—in fact, exactly where the blow is wanted. This is accomplished in a very simple manner by using an elongated weight, shod with steel, which passes down the inside of the tube. To this weight is attached a long rope, which is pulled by hand and allowed to fall, striking upon an even surface provided at the top of the bulbous point; this is the most simple form of working on this plan, and is shown in Fig. 11. Fig. 12 shows a more convenient form of working, which consists of a short shearlegs, the head of which serves as a guide for the tube, and from this head rise two tubular uprights, to carry a pulley over which the rope travels, and which can be worked either by hand, or other power. One feature of the new system is, that it does away entirely with the risk of bending the tubes when they get on to anything hard; on the contrary, the tendency is to keep them perfectly straight, and the tubes are not damaged in any way. Fig. 13 shows a plan—suitable for tubes of large calibre—for shutting out any sand, which might get in and impede the blow. It consists in providing the weight with an outer casing, in which it can freely slide up and down; the shoulder provided on the weight enables it, when withdrawn entirely, to bring the casing up with it. Another plan is shown at Fig. 14. This acts upon the pneumatic principle. The bottom pipe, about 4ft. long, without perforations, is smooth drawn and slightly smaller in its internal diameter than the tubes which follow it; the driving weight is hollow, consisting of an outer and an inner tube, the annular space being filled with lead. Near the bottom of this driving weight, which is steel shod, a rope or other suitable packing is fixed, so that it acts as a plunger. At the top of the inner tube of the driving weight is fixed a valve, which allows any air to escape as the weight drops. When the weight is lifted, a partial vacuum is created beneath it. This increases the labour of raising the weight, but the additional labour thus expended is nearly all returned in the augmented rapidity with which the partial vacuum causes the weight to fall. This plan of internal driving is found to be very applicable for driving tubes of large diameter, as the tackle required is so simple and inexpensive; it also commends itself most favourably for driving under water, as by its means a tube can be driven at the bottom of a well which is, more or less, full of water. The process is not by any means confined to well-sinking purposes. Iron piles can be most effectually, particularly where there is a great depth of water, it being quite practicable thus to drive piles 50ft. or 100ft. below the surface of the water. On a smaller scale the plan is also well adapted for driving telegraph posts with rapidity for military or permanent purposes, as well as for tubular posts for wire or other fencing. The uses to which the smaller sizes of tube wells are adapted are very various, to a great extent they supply an important want of the present day in furnishing pure water for domestic use, and thus replace the old dug wells which in most rural districts are found contiguous to cesspools, and with few exceptions are more or less contaminated by sewage. In numerous instances by driving one of these tube wells some 16ft. or 20ft. below surface springs, a pure supply can be obtained, for these tubes are found to perfectly shut off all communication from the impure water in the upper seam. To give an instance, out of many hundreds, at Brandeston Hall in Suffolk, the dug well which supplied the household being found to be impure, thereupon a tube was driven, and after passing a very compact bed of clay some 20ft. thick, chalk was met with at 36ft., and an abundant supply of perfectly pure water obtained. The smallest sized wells are advantageous for manufacturing purposes, for supplying moderate sized boilers with feed-water, not only in rural districts, but in towns supplied by waterworks, thus saving heavy water rates. Many are thus in use for similar purposes, even in the very heart of London, springs being found to exist in many spots where it might have been expected that deep sewers had drained away all the land springs overlying the London clay. As it is not uncommon for a 1¼in. tube to yield

from 500 to 600 gallons per hour, constant pumping, contractors in erecting large buildings find them very useful both for supplying their engines and for mixing mortar, and on the completion of the contract they are taken up ready for use elsewhere. This feature of being readily transportable from place to place renders them invaluable for railway contracts, and especially so for exploring expeditions, Sir Samuel Baker and others having employed them in Africa and elsewhere for that purpose. Another use to which they are daily put is for testing ground to ascertain how deep water lies below the surface, to test the quality and quantity obtainable before sinking larger permanent tube wells. It will readily be seen how valuable such a rapid means of obtaining such data becomes, as before purchasing land for any purpose, the primary question of water supply can thus be settled. The firms of Messrs. Mann and Crossman and Messrs. Truman, Hanbury, and Buxton, among many others, availed themselves of this medium to test sites of land before purchasing them for building their branch breweries at Burton-on-Trent. It will also be seen that this principle of testing land is not confined to water purposes, for it is equally adapted for testing for foundations more expeditiously than any other known plan. In fact, tube wells must daily become more and more an indispensable adjunct to the plant of engineers and others dealing with land projects generally, and the only wonder is, that such a very simple invention should not have seen light many years sooner than it did. Within the limits of a short paper like the present it is not possible to do more than very briefly to describe the smaller sized tube wells and appliances, those of larger diameter requiring more complicated apparatus.

TUBE WELLS FOR LARGER SUPPLIES.

WE have treated the subject of mechanical appliances for driving Tube Wells, and Mr. Sutcliff has added to that information a paper on larger supplies and treatment of strata. A 3 in. tube will in favourable soils yield from 1,500 to 2,000 gallons an hour. At Messrs. Allsopp's brewery the portable steam pump filled a 100 gallon cask in a minute from a 3 in. tube from a well 30 feet deep through gravel, and that gives 6,000 gallons an hour.

For large supplies it is found better to use no longer than 3 in. tubes, but to sink a number of wells and connect them by horizontal mains about 2 ft. below the surface to protect them from frost, &c., as shown in fig. 1. These mains are cast-iron flange pipes, with branch pieces placed at each tube well. A bend is attached to each branch piece, which is coupled to the tube well by a flange screwed on the well, corresponding with the flange on the bend. The number of wells can be indefinitely increased, and they should be about 20 ft. apart according to the strata. Steam pumps are attached to the mains, and one can draw from fifteen wells, and thus draw from a very much larger area than any single well yet made.

This is the method adopted at Burton-on-Trent breweries, and it produces water of equal temperature, say 51 deg. to 52. Messrs. Allsopp have 30 coupled 3 in. tube wells, and with three pumping engines draw 60,000 gallons an hour. Messrs. Bass and Co. have 25, and obtain about 50,000 gallons an hour. These two breweries obtain a sufficient supply of water for a town of 40,000 inhabitants at 25 gallons a-day for each person.

In these cases the soil is sharp gravel or sand, and the depth is but 30 ft.: below that is hard red marl with bands of gypsum almost impenetrable. These wells are within a stone's throw of the Trent, but the water is totally different from that of the river in quality, level, and temperature, and they have been worked now ten years very satisfactorily.

At Carmarthen, in Wales, the supply is derived entirely from 10 in. tube wells, and the result is described in the *Welshman* newspaper.

"The inhabitants of Carmarthen ought to be thankful that they are not as other people—in the matter of water supply. Whilst at Pembroke Dock water is being sold in the streets at a penny per gallon, and a bayonetted sentry is placed at the only remaining spring to prevent the waste of water, the people of Carmarthen—thanks to the tube wells—have an ample supply, and of excellent quality. For some months the new engine at the new waterworks has been going day and night, and the supply, so far from being diminished, has increased considerably in the past week or so. On Tuesday afternoon there was a trial test, in order to ascertain the quantity of water pumped into the reservoir in a given time, the two receiving buckets containing each 154½ gallons. The trial went on for half an hour, when it was found that the pumps had been throwing water at the rate of 9000 gallons per hour, the engine at the time making from 56 to 60 strokes per minute. This trial was of the most gratifying character, and must set at rest all doubt as to the success of the new waterworks. The recent analysis shows that the inhabitants of Carmarthen are being supplied with water of excellent quality, wherever it comes from." It is said that when these tubes were first sunk at Carmarthen, a member of the corporation thought it so impossible that ten little tubes of only 2 in. diameter could supply the whole town, that he took a chair when the pumps were first started and announced his intention not to move until the wells were pumped dry. After four hours he had to give in and exclaim, "Where does the water come from?" These works cost only £2,200, and yielded in 1874—a dry season—1,334,000 gallons a week, at a pumping cost of £156.

These coupled wells have been put down at various places. Two 3 in. wells at the Solway Hematite Iron Works, in Cumberland, have enabled the proprietors to effect an annual saving of £350 in water-rate: and at Messrs. Charles Price & Co.'s Oil Works, at Belvedere, Kent, the three 3 in. wells provides them with an ample supply of clear water, and saves them the expense of carrying mains into the Thames and then filtering to remove mechanical impurities. The water was brackish, but it was only required for refrigerating, for which purpose the Thames water in summer would be useless because of too high temperature.

Mr. Sutcliff describes the process which is illustrated by the engravings on p. 331, &c.

Before sinking a set of wells which it is intended to couple together, the ground is always tested by means of small 1¼ in. tube wells, so that full information may be obtained regarding the strata at each spot and the exact depth that it is necessary to go. This saves the larger tubes from unnecessary wear and tear, and enables the engineer to have each well the proper length, thus avoiding the cutting and screwing of tubes on the ground. Each 3 in. well is pumped until the water comes from it perfectly clear previously to making the connections with the mains. It is advisable to put a stop valve in the mains between the pumping engine and the wells; as, if from any cause the pump should lose its water, it is apt to cloud the wells. The proper treatment of the various soils is most important in making successful tube wells. An inexperienced or unskilful man will, in many cases, fail to make a well, where one properly trained will obtain an ample supply. One of the most troublesome soils to deal with is sand. In some localities water is found in strata composed entirely of fine sand, in which the ordinary tube well, with the usual-sized perforations, would soon become choked, and as fast as the sand is pumped out with the aid of the small cleaning-out tubes it will flow in at the perforations. The author heard of some Dutch sailors who drove a tube well on their coast and pumped up so much sand that the earth above caved in, and the stout Netherlanders all fell into the hole together. To overcome this difficulty a special perforated tube is employed, termed a sand tube. This is so constructed as to present a large surface of fine interstices forming a screen, which prevents all the coarse sand from entering the tube, admitting only the water and the finest particles which are easily pumped up with the water. The pointed tube is perforated for a considerable distance at its lower end, so that the total area of the perforations may be, say, ten or more times the sectional area of the pipe. Within this tube, and extending along the perforated part, an inner tube, also extensively perforated, is inserted, and around it horsehair cloth is wound in many convolutions, so as entirely to fill the outer tube. The horsehair so applied effectually stops back the sand, but it allows the water to filter into the inner tube, and from thence it passes into the main well tube and is drawn up by the pump. In the employment of this sand tube it is sometimes advantageous to make use of a vacuum chamber, and this is done by introducing a suction tube into the tube well, as shown at Fig. 2. It will be seen that the inner or suction tube is made with a top flange, which is shut in between the top of the tube well and the pump, so that when the water in the well is lowered a partial vacuum is created in the annular space outside the suction pipe.

This form of sand tube has been successfully used in many quick sands, and perhaps with the most notorious success on the Leicester race course during the Royal Agricultural Show of 1869. The weather at the time was particularly sultry, and the water from the tube well was so remarkably cold and clear that the stand was mobbed by crowds of thirsty sight-seers, in consequence of which a space was railed off and a trifling charge made for each glass of water. At the close of the show the money thus collected was handed over to the Leicester Hospital, and amounted to the respectable sum of £23. One drawback to the form of sand tube described is, that the ground has first to be tested with the ordinary tube well, which has to be withdrawn to enable the sand tube to be driven in the same

spot. Other sand tubes therefore have been designed, which can be dropped down the ordinary tube well without withdrawing it. These sand tubes have perforations of different sizes, with the object of adapting them to the various kinds of sands. If a sand has a number of coarse particles, and a smaller proportion of fine, it is advisable to use a sand tube with perforations of such size as will allow the fine to pass, but keep back the coarse. In this way a filter bed is formed, through which the water will flow much more freely than if the whole of the sand were kept back, and after steady pumping the fine sand ceases to come into the well. There are, however, some water-bearing soils which are so fine and floury in their nature that to shut them back would also exclude the water. Much thought was expended and many experiments tried in such soils; ultimately the following plan was adopted with success :—

A tube well was driven at Chiselhurst into an extremely fine sand, and it was found impossible with the horsehair strainer to get any supply of clear water. The tubes were withdrawn, and the point screwed off, and the open pipe driven into the same hole. The pump was then screwed to the top of the tubes, and four or five barrow-loads of sand pumped up. Previously to doing this, however, six barrow-loads of good, clean, sharp grit gravel were brought to the spot. The pump was removed, and down the tube, which was only 1¼ in. internal diameter, as much gravel was forced ramrod-fashion as filled up the cavity made by the removal of the sand. The open tube was then withdrawn, and a pointed and perforated tube driven into the gravel bed thus formed. A coarse sand tube was dropped into the well to keep back the grit, and upon again attaching the pump the water came freely and rapidly cleared. Fig. 3 shows the bed of gravel inserted in the manner described. In consequence of the success of this well another was sunk on the same estate with equally satisfactory results, and these two wells have now been in use over two years, and within the last few weeks a third has been added. At Orpington, in Kent, what is known as a blowing sand was dealt with somewhat similarly. Owing to the nature of the sand a cavity could not be made in it as in the previous case. A hole 6 in. or 7 in. in diameter was therefore bored and piped down with large tubes, until several feet of the quicksand had been passed through. The quicksand was removed from the pipes with an ordinary boring shell and gravel was rammed down, the large tubes being gradually withdrawn as the work progressed. The small 1¼ in. tube was then driven into this vertical graved bed as shown in fig. 4, and a good well made which gave a supply of about 200 gallons per hour. Clay was rammed tightly over the gravel to prevent drainage contaminating the well. The large tubes were entirely dispensed with before completing the work.

Another method of introducing a gravel bed was employed in a dug well at Lewisham, in Kent. The dug well became dry during last summer, and to obtain a fresh supply a tube well was driven below the bottom of it, and water in a fine silver sand obtained. Gravel was thrown into the dug well, and by its weight gravitated to the spot from which the sand was being drawn. The operation of pumping out the sand and replacing it with gravel was continued until the water became entirely free from sand, and was so plentiful that two pumps were attached to it, and the next house supplied from it. This method has not yet been tried for large supplies, but several engineers, and among them some members of this Society, have expressed a very favourable opinion of the feasibility of carrying out waterworks on a large scale in localities where quicksand has hitherto baffled all attempts at making wells. One great advantage of this gravel filter is its imperishability, and of course, if the area of the gravel bed be made sufficiently large the velocity of the water is not sufficient to bring the grains of sand within the area acted upon by the pump, and it is not, therefore, likely to become choked like a filter of small dimensions. From some gravel a few grains of sand may at times come into a tube well, and yet not in sufficient quantity to necessitate a sand tube. A grain of sand, however, getting under the clack of a pump may cause it to lose water, and when a pump attached to a tube well loses its water, it causes agitation in the soil around the perforations, and other grains of sand come to keep the first one company. If no worse harm be done, annoyance is caused by having to prime the pump before using it. To obviate this a top strainer is placed immediately below the pump, with a flange to retain it at the top of the tube. This effectully protects the working parts of the pump from injury, and can be easily got at if necessary. The greatest depth that a tube well has been sunk—within the knowledge of the author by simply driving—is 116 ft., at Deal, in Kent. The strata was brick-earth, gravel, and chalk, and an interesting illustration of how perfectly the tube well isolates the spring it draws from, was afforded. The tube 1¼ in. internal diameter was driven down 18 ft., and water of brackish quality was found. At 45 ft. fresh water was obtained, and on driving to 116 ft., water was pumped as salt as brine. Thus, the presence of fresh water between two salt springs was ascertained, and a supply for a steam flour mill and domestic purposes was secured; and although some three years have passed, the water remains as fresh and pure as ever. At Sprowston Hall, near Norwich, a 2 in. tube well was driven, and passing through contaminated water, reached a spring in the chalk at 111 ft., which analysis proved to be of unusual purity. At Strasburg, a few years back, a tube is said to have been driven to depth of 120 ft.

As an exceptional instance of the rapidity with which tubes can be driven in a favourable stratum, it may be mentioned that at the Gillingham Cement Company's works in Kent, a 1¼ in. test tube well was driven 83 ft. in a single day; a sample of water was taken for analysis and the well withdrawn in about the same time. At the Thames Haven Company's landing wharf, a test well was driven 53 ft. in one afternoon.

When a stratum proves of too dense and compact a nature to drive into, or if rock or stone be met with, the impediment is overcome by making a bored tube well. Wrought iron tubes (generally perforated up for a few ft.) of great strength, and joined together by means of steel sockets, are employed, and instead of a pointed end the tube is open, but is provided with a strong steel shoe. The method of boring is mainly the same as that employed in ordinary artesian wells, but in certain strata, such as sandstone rock, hollow boring rods are used, and the pulverised stone is pumped up through the rods, which obviates the withdrawal of the chisel and lowering of a shell to bring up the *debris*. The mode of pumping and development of supply is, however, entirely peculiar to the tube well system, and the coupling of wells together is also applicable, and in many cases advantageous.

In putting down a group of bored tube wells, it is advisable (particularly where the water runs in seams) that the pipes should be carried down to different depths, as by so doing they are less liable to rob each other than if the length of the wells was identical. They may be alternated, say one well 150 ft., the next 100 ft., and the third 150 ft. again, and so on. For town supplies, and if land be difficult to obtain, the tubes may be driven along the roadside, and the mains laid in a subway, and merely space secured sufficient for the pumping station.

The importance of the pump being directly connected with the tube wells is very great, as, by the removal of all atmospheric pressure on the water in the tube, the effect of every stroke of the pump is to draw the water to the tube, and, to prevent a vacuum, fresh water flows to the spot. Now, when water is drawn from an open well or bore pipe, the level of the spring is merely maintained by gravitation; there is no drawing of the water into the well, it simply percolates into it at the pace that the particular stratum will allow it. Further, the disintegrating action of the pumps, caused by the tilting described in the previous paper, opens all the fissures round the tube well, and adds very largely to the supply. The object of the perforations in the bored well tubes is to enable the disintegrating action of the pump to have full effect, as the jets of water sent out laterally are found to produce more marked results than the vertical movement of a column of water in the bore hole. As the boring progresses, the pipes are driven as deep as the hole has been made, or, if possible, a few inches lower. This practically closes the pipe, and allows the perforations to be utilised in the tilting of the pumps, and such a drag is put on that particular part of the bore hole that channels of supply are opened which the pump, if acting on a more extended surface, would leave undeveloped. If this process be repeated from time to time, by means of a second perforated pipe carried down inside the permanent well tube, it will be known exactly from what part of the bore hole the water really comes, and the supply is augmented and developed in detail, and is finally all utilised upon the withdrawal of the internal tube. Fig. 5 illustrates the process just described. Bored tube wells have been already made to depths exceeding 300 ft., and through limestone and other rocks, and are capable of being made to any depth that an ordinary artesian boring can reach.

It may be interesting to refer to some particular instances. At Messrs. Warwick's brewery, Newark-on-Trent, a bored tube well of 5 in. internal diameter was made about 95 ft. deep through red marl, bands of stone, and gypsum. The supply upon first connecting the pump did not exceed 1500 gallons per hour, but after four days' steady pumping and tilting, 6000 gallons per hour were obtained, and came with the greatest freedom. The pumping engine was worked by steam, and the tilting was managed by a tap in the suction pipe, which at frequent intervals admitted air, and caused the rapid alternate vertical motion

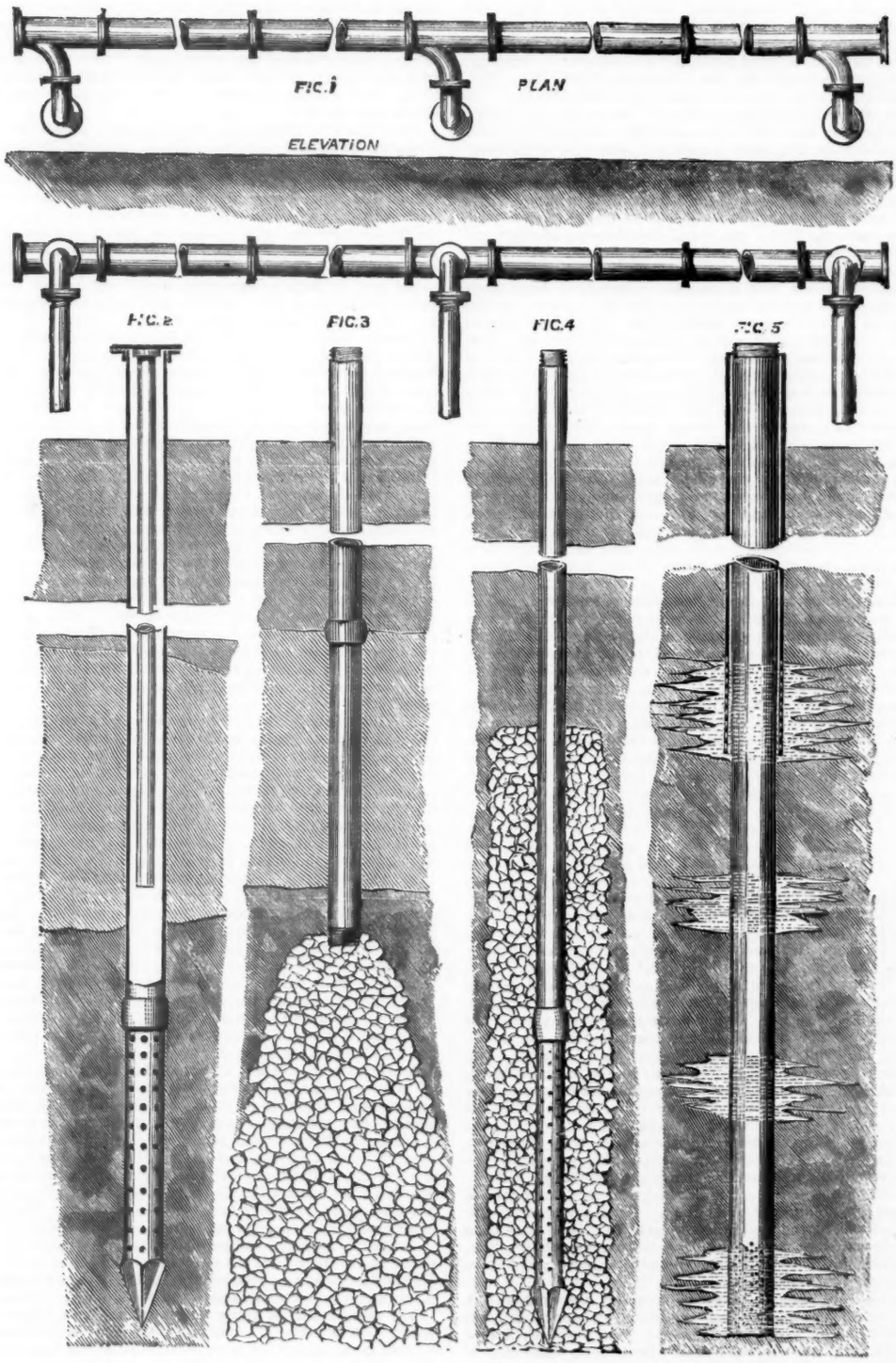


FIG.1
PLAN
ELEVATION
FIG.2
FIG.3
FIG.4
FIG.5

of the water in the tube well, which is so effectual in disintegrating the water-bearing stratum.

At Messrs. Truman, Hanbury, and Buxton's brewery, Burton-on-Trent, two 5 in. bored tube wells were put down through hard marl and gypsum to a depth of 114 ft., and coupled together, yielding an ample supply. At Birmingham one 5 in. tube well was bored through red marl 200 ft. to the sandstone, and enough water obtained to supply the Lower Grounds, Aston Park, with its ornamental waters, fountains, and extensive gardens. The proprietor of the Lower Grounds stated that by the use of this tube well he was enabled to entirely dispense with the town water, and thus save an annual rate of £300. Coming nearer home, many tube wells have been sunk in the London basin.

At West Thurrock, in Essex, about nineteen miles from London, the Tunnel Portland Cement Company is pumping from two 5 in. tube wells, about 80 ft. deep, 220,000 gallons of pure and clear water per day of ten hours. At Messrs. Lawrence and Wimble's cement works, Northfleet, one 5 in. tube well yields 60,000 gallons per day. The aggregate daily supply, therefore, of these three wells is 280,000 gallons. They have been regularly pumped for about two years, and the supply shows no sign of diminution. The cost was under £100 each. Hence for less than £300 a constant daily supply of 280,000 gallons has been obtained. The 16,000,000 gallons required by the Board of Works' scheme could, therefore, under similar favourable conditions, be obtained at an outlay of about £18,000. The water level in the tube wells at West Thurrock and Northfleet stands at only some 14 ft. below the ground level, and the pumping engines are on the surface. This fact is important, as indicating that the scarcity of water in the heart of the London basin is owing to the porosity of the chalk being insufficient to conduct rapidly a supply to meet the present demand of existing wells in the metropolis, and not to any want of water in the outer circle of the basin. At Bermondsey bored tube wells have been put down in the chalk 200 ft. deep, and at Anerley to a depth of 370 ft., but in this case it was through grey chalk which contains but little water.

Strata is all-important in the adoption of tube-wells. The tube is really a section-pipe drawing from Nature's reservoir instead of from a limited receptacle, such as a dug well. Therefore it is better to sink a series of comparatively small wells, and by drawing from several points draw a body of water that could not generally be obtained at a single spot. We see factories, breweries, and towns deriving from coupled tube wells enormous supplies, and it is not improbable that the problem of London supply will be solved by their adoption, and a constant supply of pure sparkling water take the place of the filtered dirtiness on which it now depends.

HOW TO TREAT A FARM.

AGRICULTURE is as practical a business as manufacture or engineering, and has been for the last quarter of a century a scientific operation. Its chemistry, machinery, and management occupy the attention of the keenest of Englishmen, and the results are of political as well as social importance. The old idea that a farmer was stupid and a manufacturer the opposite has been exploded a long time, and the agriculturist is now a much higher scientist than the manufacturer. He can by his judgment, skill, capital, and management, produce results that are as sure to be profitable as are those of the most adroit among machine people. He stands now, if properly qualified, on equal terms with his landlord, and is as independent as if the land were all his own. In fact as Dr. Lawes puts it in a lecture recently delivered, Agriculture is a great commercial undertaking carried on by two partners, the one providing land and buildings, and the other stock, implements, manures, and wages. The one is of course permanent, and the other has a limited ownership which we call a lease. Rent is all the one gets, the other has all the chances that are associated with general government, markets, crops and seasons. Both, if they are wise, usually succeed in producing satisfactory results.

The reason of that is that the interests are mutual. A landlord ought not to practice extortion by demanding an unreasonable rent, for if he does, he will make a bad debt or a bad tenant, and then the value of his farm is depreciated. If on the other hand, he is liberal, the farm rises in value, and the farmer's family adheres to the soil, generation after generation; making landlord life, and tenant life, honourable and pleasant.

Modern agriculture has tended to break down the old ways of making covenants as to the number of crops and the order of courses; and, following the spirit of commerce, has tended to inculcate a freedom that is mutually profitable. The restrictive policy is found to be impracticable and unjust; circumstances cause a variation that annihilate all arbitrary regulations. Restrictions do not protect the landowners, and they do not benefit the present or future tenant. If a man is not allowed to sell his straw and hay, but consume it on the farm in order to breed stock and make manure, he is driving up the prices of those goods without obtaining any personal advantage,—a very stupid procedure.

Practical agriculture has been marvellously changed of late. The conditions are different. Stock breeding, corn growing, labour cropping, have all come within the range of the influence of machinery and the knowledge derived from chemistry, to an extent that only a practical mind can realize. The agriculture of the last century consisted of taking corn crops in a prescribed succession until the land became exhausted and then it had a rest—a fallow,—where the stock might range and starve until it was again broken up. These conditions created so artificially could not endure. The man was truly bound down by prohibitions, but in revenge there were many evil things he could do without inflicting legal injury on his landlord.

Then came a rotation of crops which involved yearly ploughing, but unless old Cobbett's favourite system,—"Till's Husbandry"—were universal, and deep digging general, the plough could not do it. Manifestly spade husbandry for great farms is a monstrous absurdity. We should want a colony on every thousand acres, and the colony in these days would require wages averaging two pounds a week, for they would have to wait long intervals of idleness. The high farming is the only farming that is worth a thought in the garden or in the field. A man who does market gardening with manure four or five times a year keeps on cropping; and, what is more to the purpose, improves the quality of his produce thereby.

Few farmers find it to their interest to exhaust the land now-a-day, even so far as their covenant will permit, and although they buy cattle food and artificial manure, there is really a portion of the produce that might be sent to market which they prefer to return to the land rather than dispose of as inferior corn. To avoid the loss by these low qualities is the function of the agricultural chemist, and is a tax on the intelligence and far-sightedness of the farmer; for therein lies a considerable revenue which is more than profit, because it neutralizes what would otherwise be a loss.

An experience of forty years enables Dr. Lawes to report that after complicated experiments yearly of 80 different chemical substances, it has been found that some of the most important crops can be grown for five-and-twenty years in succession, and we remember a similar experience fifty years ago in Sussex where a large common was enclosed by the town authorities, and the intelligent manager run on his wheat-crop year after year, and so he did the oats, to the astonishment and more of the farmers of that county, in which moreover he was not a farmer at all, only what we call in these elegant days, an administrator. This was effected by chemical salts alone, possessing three essential constituents, nitrogen, phosphoric acid, and potass. The knowledge of this fact came from the use of several manures and watching their effects: these manures were then placed under chemical analysis; that science has in consequence been practically a creation, for it is not, as a science, of greater age than 25 years. These experiments and analyses enable us to form a judgment on the question how far the constituents of the crops are derived from the atmosphere, and how much from the soil.

It must be thoroughly accepted that the three constituents of manures—nitrogen, phosphoric acid, potass—are the most effective in the growth of crops, but that in proportion to their service they are only a small proportion compared with the constituents derived from the soil. The relative economy of manure made by stock, and that derived from external sources, is a subject of itself requiring separate consideration, involving questions of natural fertility, the adaptation of the land to plant food, and the prices at which the straw, hay, &c., could be more profitably consumed on, or sold off the farm.

Artificial manures alone have for two-and-twenty years yielded an average crop of three tons an acre, and a twice break during that period; a second crop has been cut without further manuring, and yielded two tons and a half more.

The same result is recorded of a wheat crop for twenty-five years. From every acre there has been taken 36¾ bushels of dressed corn, and two tons of straw. This year it is 40 bushels, and 1 ton 14 cwt. of straw. But the land has had no dung for 38 years.

Barley is differently treated. The artificial manure contains only nitrogen and phosphoric acid *without potass*. That has brought annually for twenty-five years an average of 6 quarters

of barley and 6½ tons of straw an acre, and here there has been no application of dung for thirty years ; proving that the soil has yielded as much potass as was required.

The general opinion that root crops are more dependent on applied manure than others is fully confirmed. The Rothamsted farm, with the exception of three years during which barley was grown without manure, roots have grown over eight acres without manure, without farmyard and different artificials, from 1843 to now.

Norfolk Whites	... ...	6 years.
Swedes	... ...	4 „
(Barley)	... ...	(3) „
Swedes	... ...	15 „
Sugar-beet	... ...	5 „
Mangel-wurzel	... ...	2 „
		32 years.

In the two first both leaves and roots were removed from the land ; in the two last the leaves remained and the roots only taken away. In 1876 the mangels with artificial manure alone of nitrous acid and potass was 22 tons 11 cwt., and in the present year 22 tons, 2 cwt. There has no dung for 40 years.

Large mangels are not the best. Twenty-six inches between the rows, and 11 in. from plant to plant in the rows will give a greater proportion of dry and solid matter than the monster specimens and yield 9 to 10 cwt. of sugar, which is more than *they* supply.

From these facts it is evident to our instruction that cultivated soils whether here or elsewhere that have been never cropped can be restored to fertility by the introduction of one, two, or all the three essential components of artifical manure before described.

About 90 to 95 per cwt. of the dry substance of the crops grown by artifical manures consist of organic matter ; which as the manures had none, were derived from the atmosphere.

The Earl of Leicester may be said to have been the founder of modern agricultural science. By it he converted a vast unprofitable wilderness. It was not worth 5s. an acre, and is now worth £5. He had to endure a little obloquy from what the farmers thought to be extortion, but he persevered with his system by making covenants, permitting the sale of meat and grain, but prohibiting the disposal of hay and straw, thereby conserving—nitrogen, phosphoric acid, and potass. By the sale of £10 worth of meat the tenant only sent off 18 lbs. nitrogens from the farm, but if he sold £10 of clover hay, the poor land lost 120 lbs, and in meadow-hay 80 lbs. Of phosphoric acid £10 worth of meat took off 10 lbs.; but the same value in clover abstracted 32 lbs., and of hay 23 lbs. Of potass £10. worth of meat took away only 1⅓ lbs ; in clover hay 103 lbs ; in meadow hay 90 lbs. Again of nitrogen in £10 worth of corn he would only send off 20 to 30 lbs, and in the same value of straw he would export two or three times as much. And of potass in £10 worth of corn he would lose 7 or 8 lbs.; but in the straw much more than 10 times that quantity.

Modern Science has confirmed the rough judgment of the good Earl, and it must be remembered more than confirmed it ; for £10 at that time was a very different basis of calculation than that now necessary.

To illustrate the matter in a practical way, let us assume that the farmer of 1807, and the farmer of 1877, were each permitted to sell the products, the sale of which is at present prohibited, on condition that he purchased and brought on to the land the amount of nitrogen, phosphoric acid, and potass which he carried off in the produce sold. Of course this would have been impossible in the case of the farmer of 1807, as the necessary artificial manures were not then in the market. But, assuming that the same sources were available to him, and at the same prices as at present, how would the case stand ? After selling £10 worth of the produce, the sale of which is now prohibited, the farmer of 1807 would have to expend about 111 shillings to restore the constituents exported, leaving him only 89 shillings out of the £10 received. The farmer of 1877, exporting much less than £10 worth of these products, would have to expend only about 69 shillings to return the nitrogen, phosphoric acid, and potass, retaining in his pocket 131 shillings of the £10 he had received, or about 1½ times as much.

From all of which we learn that the sooner restrictive covenants are abolished, and artificial regulations in general use between landlord and tenant are also abolished, both will be much better off.

BAMBOO FOR PAPER MAKING.

BAMBOO is not likely to be lost sight of as a natural fibre suitable for paper-making and other purposes, while Mr. Routledge is engaged in that manufacture. We have on two occasions noticed the efforts and counsels he has made public property, and are pleased to add to those notices further evidence and instructions on the subject from a letter addressed to Sir Joseph Hooker by Mr. Robert Thomson, the Government botanist, who has so successfully established Cinchona cultivation at St. Andrews, in the island of Jamaica. "It is," says Mr. Routledge in his note enclosing the above named letter, "well known that when the bamboo reaches full maturity, which ranges from 40 to 60 years, it flowers, seeds, and dies ; thus it happens that whole districts in India—where bamboo is in universal use, and is almost indispensable for building and other purposes—are deprived of this valuable material, or have to procure it from distant places at enhanced cost until after sufficient years elapse for the new plants to attain their development. This letter shows that the bamboo can be propagated rapidly by planting, and, also, that by judicious cropping a continuous and certain supply of paper-making material may be secured."

"Dear Sir Joseph,—I have thought of writing to you for some time on the subject of your remarks in the last annual report about Kew Gardens, on bamboo as material for paper-making. I have taken much interest in the subject, and have been in communication for some time with the largest firm of American paper exporters with the view of establishing the export of the raw material on a large scale from this island : I have also in my reports to the Government often referred to bamboo as being one of the most important paper-making materials ; and the *European Mail* and the *Planter's Gazette* have recently made notes on the encouraging prospects Jamaica has in this regard.

"Cutting the bamboo stems *en masse* would, as you say, destroy the plants, but I would remark that this destruction of the plants can be effectually prevented by the adoption of a different process of cropping. Thus, if instead of cutting all the stems simultaneously a proportion of matured stems is retained—a small proportion sufficient to maintain the vigorous action of the roots—the stems thus retained for the preservation of the roots may be of moderate size, and indeed may be lopped so as to superinduce the sprouting of branches and foliage near the ground. Another point to be observed consists in the manner in which the young, succulent stems are cut. They should be cut—that is, the crop for making paper—not close to the ground, but a few nodes above the ground should be left. This plan ensures the sprouting of branches and foliage from some thus left, and maintains the unimpaired action of the roots.

"The continuity of supply of the bamboo by the adoption of this plan aggregated to a very considerable quantity each year ; and, as has been seen, a bamboo plantation may be kept up indefinitely in regard to time.

"I have seen three tons of full-grown stems obtained from a bamboo clump, covering only a few square yards. This would be an enormous quantity per acre. By the system of cropping which I propose, each succulent stem, in that condition in which a penknife is easily passed through it when dried, averages only about three pounds in weight. As many thousands of these are obtainable per acre annually, I feel sure that some ten tons of paper stock could be procured from each acre annually ; putting it even at the half of this, the cultivation would prove highly remunerative.

"The system of reserving a due proportion of growing stems, by which systematic thinnings would be constantly obtainable, is so obviously advantageous, that I think it would entirely supersede the plan proposed by you, namely, growing bamboo like the sugar cane, and to replant after cutting the crop. Bamboo cuttings, though they root immediately, require to be planted a long time, certainly over two years, before they produce large and vigorous stems, suitable for paper making.

"It is a pity that some method could not be devised for utilising the ripe bamboo stems in paper manufacture. Some years ago hundreds of tons of the ripe stems were exported from here to America, which stems, I have been informed on reliable authority, were made into paper ; this trade was brought to a close owing to some difficulties in the monetary affairs of the merchant in New York to whom the bamboo was consigned. An almost incredible quantity of ripe bamboo is procurable from each acre of land, and I find that the ripe bamboo is used in China for paper manufacture. In a most

interesting "Catalogue of the Chinese Imperial Maritime Customs" collection of products at the Philadelphia Exhibition, published by the authority of the Inspector-General of Chinese Maritime Customs, the following account is given of the process of treating the bamboo stems:—"The method of preparation from bamboo is as follows: the bamboo is stript of its leaves and split into lengths of three or four feet, which are packed in bundles and placed in large water tanks; each layer of bamboo is then covered with a layer of lime, water is poured on till the topmost layer is covered. After remaining in this condition three or four months, the bamboo becomes quite rotten, when it is pounded into pulp in a mortar, cleansed and mixed with clean water. This liquid is poured in quantities sufficient for the size and thickness of the sheets required, upon square sieve-like moulds. These sheets (of which a skilful workman can make six in a minute) are allowed to dry, then taken from the mould and placed against a moderately-heated wall, and, finally, exposed to the sun to dry. The best quality is made from the shoots of the bamboo, with alum added to the infusion; the second from the bamboo itself, though a higher grade of this quality is attained by the previous removal of the green portion.

"I would add that the prices of paper made from the bamboo in China range from 3 dols. 61 cents to 21 dols. per *pecul* (133½ lbs.).—I remain, dear Sir Joseph, yours truly,

"ROBT. THOMSON."

TELEPHONY: NEW MACHINERY.

IN offering one more contribution on this subject it seems to be required that our opinion should be expressed beyond what has been already stated in these columns. The daze of fashion is reducing to frivolity what deserved a better treatment, and is attracting a class of idle speculative adventurers that ape scientific knowledge, and have no love for results that are not directly monetary, or at any rate yield them what is called fame—an ambition that in itself is of the most degradingly contemptible that can delude a human imagination; but which, when based on the solid foundations of knowledge, and the love of truth that benefits mankind, is of the most laudable among emotions. The toy-shops are digging up buried amusements, and the little provincial towns are invaded by wandering scientific theatricals; when we have only touched the borders of a region which may prove to be a mirage, or a fruitful field, but which is described by advertising selfishness or gaping wonderment. The subject is essentially scientific, and hitherto is of no use whatever; it can be made useful we hope, but until that practical aspect becomes more obvious, every lover of science must join in a protest against mountebank performances that may amuse leisure-loving people, but would not attract the earnestness of childhood.

In fact the general treatment of science in America, or those who "hail" from that land of wondrous activity and ingenuity, is becoming a topic of observation likely to produce remonstrance such as those who give would regret, and those who receive it should. There is not a "scare" in mechanics, mining, or natural science, but what either emanates from, or finds a counterpart in, the perennial stream of its current publications: and Europe has begun to distrust what in many cases ought not to be distrusted, simply because of this unending flow of change couched in terms that smack of science, and are employed therein, but which by association convey mere inflated notions that have but very little practical value.

Having thus given utterance to our caution we give the description of a talking telephone as it appears in the *Scientific American*, and, notwithstanding an insuppressible incredulity shall be glad to hear of its future success:—

"Mr. Thomas A. Edison recently came into this office, placed a little machine on our desk, turned a crank, and the machine inquired as to our health, asked us how we liked the phonograph, informed us that *it* was well, and bade us a cordial good night. These remarks were not only perfectly audible to ourselves, but to a dozen or more persons gathered around, and they were produced by the aid of no other mechanism than the simple little contrivance explained below.

"The principle on which the machine operates we recently explained quite fully in announcing the discovery. There is, first, a mouth-piece, across the inner orifice of which is a medal diaphragm, and to the centre of this diaphragm is attached a point, also of metal. This point rests against a brass cylinder supported on a shaft which is screw-threaded, and turns in a nut for a bearing, so that when the cylinder is caused to revolve, it also has a horizontal travel in front of the mouthpiece. It will be clear that the point on the metal diaphragm must, therefore, describe a spiral trace over the surface of the cylinder. On the latter is cut a spiral groove of like pitch to that on the shaft, and around the cylinder is attached a strip of tinfoil. When sounds are uttered in the mouth-piece, the diaphragm is caused to vibrate, and the point thereon is caused to make contacts with the tinfoil at the portion where the latter crosses the spiral groove. Hence, the foil, not being there backed by the solid metal of the cylinder, becomes indented, and these indentations are necessarily an exact record of the sounds which produced them.

"It might be said that at this point the machine has already become a complete phonograph or sound writer, but it yet remains to translate the remarks made. It should be remembered that the Marey and Rosapelly, the Scott or the Barlow apparatus, which we recently described, proceed no further than this. Each has its own system of caligraphy, and after it has inscribed its peculiar sinuous lines, it is still necessary to decipher them. Perhaps the best device of this kind ever contrived was the preparation of the human ear made by Dr. Clarence J. Blake, of Boston, for Prof. Bell, the inventor of the telephone. This was simply the ear from an actual subject, suitably mounted, and having attached to its drum a straw which made traces on a blackened rotatory cylinder. The difference in the traces of the sounds uttered in the ear was very clearly shown. Now there is no doubt that by practice and the aid of a magnifier, it would be possible to read phonetically Mr. Edison's record of dots and dashes, but he saves us that trouble by literally making it read itself.

The reading mechanism is nothing but another diaphragm, held in a tube on the opposite side of the machine, and a point of metal which is held against the tinfoil on the cylinder by a delicate spring, so that the metal point is caused to vibrate as it is affected by the passage of the indentations. The vibrations, however, of this point must be precisely the same as those of the other point which made the indentations, and these vibrations, transmitted to a second membrane, must cause the latter to vibrate similar to the first membrane, and the results is a synthesis of the sounds which, in the beginning, we saw, as it were, analysed.

"In order that the machine may be able exactly to reproduce given sounds, it is necessary, first, that these sounds should be analysed into vibrations, and these registered accurately in the manner described; and, second, that their reproduction should be accomplished in the same period of time in which they were made, for evidently this element of time is an important factor in the quality and nature of the tones. A sound which is composed of a certain number of vibrations per second is an octave above a sound which registers only half that number of vibrations in the same period. Consequently if the cylinder be rotated at a given speed while registering certain tones, it is necessary that it should be turned at precisely that same speed while reproducing them, else the tones will be expressed in entirely different notes of the scale, higher or lower than the normal note as the cylinder is turned faster or slower. To attain this result there must be a way of driving the cylinder, while delivering the sound or speaking, at exactly the same rate as it ran while the sounds were being recorded, and this is perhaps best done by well-regulated clockwork. It should be understood that the machine is at present in an experimental form, and combines in itself two separate devices—the phonograph or recording apparatus which produces the intended slip, and the receiving or talking contrivance which reads it. Thus, in use, the first machine would produce a clip, and this would, for example be sent by mail elsewhere, together in all cases, with information of the velocity of rotation of the cylinder. The recipient would then set the cylinder of his reading apparatus to rotate at precisely the same speed, and in this way he would hear the tones as they were altered."

LIGHTNING CONDUCTORS.

By DR. MANN, Vice-President of the Meteorological Society.

ENQUIRIES having been made during the summer for information on certain points concerned in his method of protection from accident, I wish to answer the appeal.

There is no doubt whatever that insulating supports are not required by lightning rods. When the earth connection of the lightning rod is of ample dimensions and complete, it is not of any practical moment whether the rod

itself is attached to the building by metallic clamps or by earthenware supports. Even with an imperfect earth contact, the insulators ordinarily employed are of no use, because a high tension lightning discharge makes its way through such a puny obstacle as an inch or so of earthenware with the utmost facility. A moment's reflection will make this apparent, since it is no uncommon thing to hear of a lightning discharge leaping disruptively through a stone wall two yards in thickness, as if it were merely a sheet of pasteboard interposed in its path. What is really required is that the discharge should be deprived of its high tension, and be converted, as far as may be, into a gentle and continuous stream, which has no tendency to burst away from the conducting path. This is what is accomplished when a proper earth contact is provided for the rod ; a spacious outlet for the escaping electric stream is in that way opened at the base. The most convenient and ready expedient by which this may be done is by packing about three bushels of coke closely round the lower termination of the rod, laid along in a trench cut into the ground to an extent of about 20 feet.

A copper band is assuredly a better lightning conductor than a twisted rope of copper wire of corresponding dimensions, because the rope is liable to be molecularly strained in the process of manufacture, while the copper strap, or band, is actually improved for its work of electric conductor by the process of rolling which it has passed through. The size of the conductor is matter of more importance than is generally conceived, for two distinct reasons, which both require to be taken into account. In the first place, a ½ in. rod of copper is certainly not a "sufficient protection in all circumstances." The resistance, and therefore the comparative inefficacy of a lightning rod, increases with its length as well as with its smallness. A rod which is employed to protect a building 160 ft. high requires to be as large again as the one that is used for a building 80 ft. high and twice as large again for a building 240 ft. high. A considerable proportion of the accidents from lightning in towns occur to very tall chimney stacks, most probably occur from this very cause. When the conducting rod of a tall chimney shaft is of insufficent dimension for its conducting work, there is always a ready temptation for the discharge to leap across the brickwork to the heated air and soot-covered surface within the shaft, which too often have a better communication with the earth than the outer rod. If my memory does not deceive me, there was one notable instance in the experience of Mr. Gray, the associate and successor of Sir William Snow Harris, in which a copper wire rope three-quarters of an inch in diameter proved insufficint for the protection of the lofty tower of St. Mary's Church at Taunton.

The copper tube which was so efficiently used by Sir William Snow Harris in his system of protecting ships was virtually a copper strip, or band, turned round upon itself into the form of the tube. The flat band has an advantage over the tube for land use, chiefly on account of its flexibility and ready adaptability to irregular surfaces, which it shares with rope ; of the readiness with which it can be rolled to any required length, and can be made of any desired thickness and breadth ; and of the facility with which it can be coiled for transport. The passage from the form of the tube to that of the strap, or band, was a natural transition. I believe that strap form of conductor has been employed by Mr. Gray, the successor of Sir W. Snow Harris, for a considerable time. It certainly, on the whole, constitutes the best kind of lightning rod that can be adopted ; and great service has been rendered by the various manufacturers who have recently improved and simplified the process of manufacturing the copper tape is this flexible and convenient shape.

There is, however, another point of view in which the size of the lightning rod has to be contemplated, and this needs to be very carefully noticed, because it is so habitually overlooked in most references to the question. A lightning rod may be quite large enough not to be fused or destroyed by an electrical discharge, and yet to be so small that it very materially impedes the free flow of the electric force passing through it. The resistance offered by a conducting rod to the passage of a discharge of lightning is in proportion to the smallness of the rod. The smaller the rod the more leapingly and, so to speak, "disruptively," the discharge must make its way through the conducting mass. The smallness of the rod, therefore, favours the high-tension tendency of the discharge, or, in other words, gives it increased inclination to find a devious path by lateral and erratic outbursts, instead of following the course intentionally provided for it. For this reason it is well that the capacity of the rod should be made as large above the real standard size that is conceived to be sufficient to withstand the fusing power of lightning as circumstances allow. A lightning rod that would only just escape fusion and destruction from a discharge, would certainly be a very insufficient protection against accident. The imperfect apprehension of this principle, again, is one which in all probability is not an unfrequent cause of mischief.

I am somewhat anxious here to say that I think the old dogma, that "a conductor does not attract electricity any more than an umbrella attracts rain," cannot now be received in an absolute and unqualified sense. A conductor in the near presence of a charged thundercloud becomes inductively excited, a very strong charge of the opposite kind of electricity to that in the cloud being drawn to the top of the rod. When this state of things has been brought about, there certainly is a stronger tendency for a spark or flash to pass across the intervening air-gap than there would be in the absence of any such inductive disturbance. The electricians who still hold this view would probably, nevertheless, hesitate to carry their argument home to its ultimate conclusion, by saying that there is no attraction between the outer and inner coating of a charged Leyden jar, immediately before the electric forces shatter the glass, to effect the discharge of the jar. The charge of a Leyden jar is chiefly due to the attraction of the several electric forces exerting themselves to unite through the insulating barrier of the glass. The charge in the outer coating of the jar, comes up from the earth under the attraction of the inner charge.

WHAT IS A BILLION?

MR. BESSEMER writes to the *Times* a letter which we cannot withhold from our readers, for it deserves a more permanent position than can be hoped for in newspaper contents :—

"It would be curious to know how many of your readers have brought fully home to their inner consciousness the real significance of that little word "billion," which we have seen of late so glibly used in your columns. There are, indeed, few intellects that can fairly grasp it and digest it as a whole ; and there are, doubtless, many thousands who cannot appreciate its true worth even when reduced to fragments for more easy assimilation. Its arithmetical symbol is simple and without much pretention ; there are no large figures—just a modest 1 followed by a dozen cyphers, and that is all.

Let us briefly take a glance at it as a measure of time, distance, and weight. As a measure of time, I would take one second as the unit, and carry myself in thought through the lapse of ages back to the first day of the year 1 of our era, remembering that in all those years we have 365 days, and in every day just 86,400 seconds of time. Hence, in returning in thought back again to this year of grace 1878, one might have supposed that a billion of seconds had long since elapsed ; but this is not so. We have not even passed one-sixteenth of that number in all these long eventful years, for it takes just 34,687 years, 17 days, 22 hours, 45 minutes, and 5 seconds to constitute a billion of seconds of time.

It is no easy matter to bring under the cognisance of the human eye a billion objects of any kind. Let us try in imagination to arrange this number for inspection, and for this purpose I would select a sovereign as a familiar object. Let us put one an the gronnd and pile upon it as many as will reach 20 ft. in height ; then let us place numbers of similar columns in close contact, forming a straight line, and making a sort of wall 20 ft. high, showing only the thin edges of the coin. Imagine two such walls running parallel to each other and forming, as it were, a long street. We must then keep on extending these walls for miles—nay, hundreds of miles, and still we shall be far short of the required number. And it is not until we have extended our imaginary street to a distance of 2,386½ miles that we shall have presented for inspection our one billion of coins.

Or in lieu of this arrangement we may place them flat upon the ground, forming one continuous line like a long golden chain, with every link in close contact. But to do this we must pass over land and sea, mountain and valley, desert and plain, crossing the equator, and returning around the southern hemisphere through the trackless ocean, retrace our way again across the equator, then still on and on, until we again arrive at our starting point ; and when we have thus passed a golden chain around the huge bulk of the earth, we shall be but at the beginning of our task. We must drag this imaginary chain no less than 763 times round the globe. If we can further imagine all these rows of links laid closely side by side and every one in contact with its neighbour, we shall have formed a golden band around the globe just 52 ft. 6 in. wide ; and this will represent our one billion of coins. Such a chain, if laid in a straight

line, would reach a fraction over 18,328,445 miles, the weight of which, if estimated at ¼ oz. each sovereign, would be 6,975,447 tons, and would require for their transport no less than 2,325 ships, each with a full cargo of 3,000 tons. Even then there would be a residue of 447 tons representing 64,081,920 sovereigns.

For a measure of height let us take a much smaller unit as our measuring rod. The thin sheets of paper on which these lines are printed, if laid out flat and firmly pressed together as in a well-bound book, would represent a measure of about 1-333d. of a inch in thickness. Let us see how high a dense pile formed by a billion of these thin paper leaves would reach. We must, in imagination, pile them vertically upward, by degrees reaching to the height of our tallest spires; and passing these, the pile must still grow higher, topping the Alps and Andes and the highest peaks of the Himalayas, and shooting up from thence through the fleecy clouds, pass beyond the confines of our attenuated atmosphere, and leap up into the blue ether with which the universe is filled, standing proudly up far beyond the reach of all terrestrial things; still pile on your thousands and millions of thin leaves, for we are only beginning to rear the mighty mass. Add millions on millions of sheets, and thousands of miles on these, and still the number will lack its due amount. Let us pause to look at the neat ploughed edges of the book before us. See how closely lie those thin flakes of paper, how many there are in the mere width of a span, and then turn our eyes in imagination upwards to our mighty column of accumulated sheets. It now contains its appointed number, and our one billion of sheets of *The Times* superimposed upon each other, and pressed into a compact mass has reached an altitude of 47,348 miles!

Those who have taken the trouble to follow me thus far will, I think, agree with me that a billion is a fearful thing, and that few can appreciate its real value. As for quadrillions and trillions, they are simply words, mere words wholly incapable of adequately impressing themselves on the human intellect.

THE PRODUCTION OF SOLUBLE GLASS AND SILICATE OF POTASH.

GLASS production has obtained the notice of scientific men in England for the last three hundred years, and it is amazing to observe the ignorance that prevails in our time. The most brittle and the most ductile of metals it is only quite of recent date that the intelligent public have taken any notice of the countless and hopeful experiments have been made, and of the rational theories that have been propounded by those who certainly know; which theories lie among the wealthy number of the last fifty years, to be recovered, we suppose, by somebody fifty years hence; persons who will claim to be inventors but who live by foraging among the ruined hopes of good and qualified men. In connection with a paragraph in another part of this volume upon the application of glass-founding for the manufacture of type we now notice an article that has appeared in *Dingler's Polytechnische* journal on the production of Soluble Glass from the *farnil fossile*,—a glass containing wealth of manufacturing and chemical substances that is all but ignored.

It appears that, with that exception of a small production of silicate of potash, the makers of soluble glass have not made any use, or very little, of this peculiar form of soluble silicic acid. The old methods are still in favour, the principal of these being two; one, that which is employed in England, and the other that adopted on the Continent. In the English method the glass is produced by boiling selix in a caustic solution, while on the Continent the mode is, first to make glass with sand, sulphate of soda, and charcoal; afterwards, to render it soluble by means of the action of steam under high pressure. M. Capitaine does not think that the *farine* can compete in cheapness with flint when the latter is abundant, but then it has the advantage of being much more soluble.

Flint, broken up into pieces of about a cubit centimetre and submitted under a pressure of steam of 4½ to 6 atmospheres, to the action of an alkaline lye of the density of 1·25 to 1·30, for six or eight hours, yields glass which is very alkaline and caustic, containing about one part of silica. With *farine fossile* a lye of 1·2 density, and a pressure of three atmospheres are employed, and in three or four hours' process there is a yield of a much more neutral glass than the preceding, containing about three parts of silica to one part of alkali.

The production of silicate is said to be very easy with *farine fossile*, and M. Capitaine thinks that the causes which have prevented the *farine* being used instead of flint are purely accidental.

The *farine* is first calcined, an operation which takes a long time, because not a trace of the organic matters found in natural earths must be allowed to remain in the product; if this condition be not observed the solution obtained by means of the lye will have a yellowish or brownish tint, which will make it difficult of sale. The mineral is a bad conductor of heat, so that it does not calcine with facility. This inconvenience alone has perhaps caused the *farine* to be neglected by the makers of soluble glass on the score of economy. It is only within a short time that MM. Grüne and Hangermann have produced the calcine product at a relatively low price, and have thus afforded the humid process with *farine fossile* is not really preferable to the employment of flint.

M. Capitaine, with this idea, undertook a series of experiments on a large scale. The lyes being prepared partly with caustic soda and partly with carbonate of soda, had densities ranging from 1·22 to 1·24, which were found to be the most advantageous. A reservoir, furnished with mechanical agitators, was about two-thirds filled with lye and the necessary quantity of calcined *farine* added, the stirring being kept up continually. The proportion of *farine* is easily calculated on the *datum* that one part of hydrate of soda dissolves about 2·8 parts of chemically pure *farine*, the quality of which varies but little. Lye of the density indicated produces a rather light solution which presents little resistance to the agitators. If steam is afterwards introduced, the solution becomes very rapid when the pressure reaches about three atmospheres, and at the end of about three hours the silica is completely dissolved. Practice soon shows when the operation is complete by the colour of the liquid, and by the fact that a sample taken out of the reservoir clarifies very rapidly. The colour of the foreign matters then in suspension is of a dark red brick. If an excess of *farine* has been employed, or the boiling has not been continued sufficiently long, the colour will be of a reddish white, and the solution will not clear itself when allowed to stand at rest. A small excess of silica left undissolved will cause the solution to remain turbid for a very long time, and it is extremely difficult to get rid of the excess by filtration. But this inconvenience is easily avoided by care in practice, and a uniform solution is obtained, which clears itself readily. One condition must, however, be always observed. If the lye be too concentrated, of a density of 1·3, for instance, the solution precipitates but very slowly the fine sand and oxide of iron which it holds in solution; a week is hardly sufficient for this to be completed. Too strong a lye should, therefore, not be employed; the density of the solution should not exceed 1·18.

If the silicate has a density exceeding 1·18, the best way is to reduce it by the addition of water; the clarification will proceed very quickly, and at the end of four-and-twenty hours the liquid will be perfectly white and clear. The deposit which is thrown down, composed of sand and oxide of iron, is rather more abundant than in the case of a solution of flint, but it is easily washed, and if mixed with diluted soluble glass, forms good glaze or dressing.

For the preparation of silicate of potash, which is to contain as strong a dose as possible of silica, for surgical purposes, the *farine fossile* is said to be peculiarly adapted. In this case the boiling must be continued for one or two hours longer than in the case of soluble glass, with an addition of 10 to 15 per. cent of *farine*; by these means a liquid is obtained rich in silica, which begins to congeal when its density is 1·32.

Farine fossile may also be employed in combination with flint. A glass is first produced from flint, which is afterwards converted into a neutral silicate by being well agitated with *farine* in a second vessel; or, a single apparatus may be made to suffice, by adding to the flint the necessary quantity of *farine*.

SAFETY-VALVES.

SAFETY-VALVES are of the utmost importance, says Mr. Cresy in his invaluable encyclopedia of Civil Engineering, and the greatest care should be bestowed on their construction. The observation of this distinguished engineer is probably correct from the fact that more than a hundred and fifty patents have been taken out for improvements in their construction. Whether a safety-valve absolutely perfect is attained or not must be left to time and circumstance. The imperfection of all human work, and indeed of all natural operations, leads to the fear that science will never reach an exactitude that shall prohibit, or render futile, all further effort. But the endeavour

is persistent as is seen not only in the wit of inventors but in the character of their work.

The earliest of these necessities of the steam engine consisted of a mere weight laid on a hole on the top of the boiler, and that manifestly was bound to fail when Trevithick put forth and put in practice high pressure. The weight became unsteady and would have gone to the moon had not the men of science observed its helplessness and devised a valve with a spindle that rising upwards carried a series of weights of less or greater value. That led to a valve with an internal weight; but pressure made that cumbrous. Then came the lever, which was a single weight hung at the end—like a steelyard—and the weight acted on light rollers that by their movement indicated the prescribed limit. This did not suffice, and recourse was had to springs to keep the end of the lever down and indicate danger.

How to balance the pressure of steam certainly and safely even in low-pressure boilers excited the attention, and induced the experiments of engineers; and the best method appeared to be, by a column of water of a diameter sufficient to allow its escape: and on that question of diameter turned all the conclusions. Mr. John Bourne has formulated the principle in his book (1865). "It is easy to determine what the size of an orifice should be in a boiler to allow any volume of steam to escape through it in a given time. Atmospheric pressure at 15 lbs., and steam pressure from the boiler at 25 lbs., the velocity of the outflowing steam equals that which a heavy body would require in falling from the top of a column of the denser fluid that is high enough to produce the less pressure, which pressure is easily ascertained by the law of falling bodies. But, in practice, the area of the safety-valve is made larger, partly because valves are liable to stick round the rim, and because in large valves the circumference becomes relatively less.

"One approximate rule for safety-valves is, to allow one square inch of area for each inch of cylinder-diameter; thus, an engine with 64-inch cylinders requires a safety-valve on the boiler of 64 inches area, *i.e.*, a diameter of 9 inches. The rule must be made in condition to mathematical rules which belong to constructive engineering, and subject to variations according to data placed in your power as to size, object, high or low-pressure, and upon the number of boilers and otherwise. The general principle is, that the area of the waste steam-pipe should be the same as that of the safety-valve."

Of the hundred and fifty inventions, we notice the latest which is accounted to be the best for "preventing explosions from over-pressure of steam." Its trade designation is "Smith's Patent Steam 'Sentinel' Safety Valve," and in several cases it has guarded the action of three boilers in one set of works, and when set to blow off at 140 lbs. pressure. It is said to be the simplest and most efficient valve ever designed—keeping the stokers to their work, and protecting the property from any risk of ruin by its stern indications of danger from over-pressure. Indeed some report that accidents are all but impossible where they are used. Their employment on Cornish boilers, and on verticles, gives apparently equal satisfaction.

It combines a perfect safety-valve, a pressure indicator, and an alarm, and being enclosed cannot be tampered with. The simplicity is apparent when it is stated that in two hours it can be fixed to any boiler; and when fixed it checks ordinary pressure gauges and safety-valves, guarding against overloading or carelessness, and giving intimation of excessive pressure from any cause.

In its construction it is double-seated, thereby preventing the steam having access to the spring; and every spring is copper-coated.

The steam, after leaving the valve, passes up direct through the centre of the valve spindle, thereby getting a perfect direct thrust on the spring, and compressing the same, so as to relieve the boiler at once of the undue pressure. The valves and hollow spindle are fitted to the guides; both are on the knife-edged principle, thereby preventing any resistance in the action of the valve when the fixed pressure is exceeded. The sentinels can be fitted with a lever if required for lifting the valve.

This invention is in the hands of Messrs. William Thomson and Co., Queen Victoria Street, London.

To be continued.

GERMAN COAL.

THE growing development of the trade and consumption of German coal, and the great efforts which have been and continue to be made towards enabling German coal not only to drive its British rival out of the markets of Germany itself, but also to enter into successful competition with the latter as an article of exportation to foreign countries, are facts of so much importance for the interests of all classes at home who are connected with the British coal trade, that Consul Perry devotes a considerable space to this subject in his last report upon the trade of Bremen.

It is doubtless well known, he observes, that the most extensive of the coal fields of Germany are those of Westphalia, and that during the last ten or fifteen years the production of coal, as well as all other branches of industry in that province, have developed themselves in a very striking degree. It is unquestionable that, whilst nearly all other branches of manufacturing industry in Germany have continued to suffer during the last two years under the effects of former excessive production and general commercial depression, the condition of the Westphalian coal industry has become a more and more favourable one. In the course of the year 1875, the general sphere of consumers of coal was greatly extended in Central, West, and North Germany; and Westphalian coal is now in use in many places where formerly either other kinds of fuel, viz., peat, wood, &c., were chiefly employed, or where it was found cheaper and easier to import coal from Great Britain or to a small extent from foreign countries. But by far the most important, however, amongst the districts or towns recently opened up for the consumption of Westphalian coal, are the two chief commercial cities and seaports of Germany, viz., Bremen and Hamburg. The completion of a nearly straight line of railway connecting these cities with the coal fields of Westphalia, the reduction of the rates of carriage for coal on this line, and other steps taken by the leading merchants of Bremen and Hamburg, in conjunction with the coalpit proprietors and the railway companies interested in the subject, have already had the effect that British coal is gradually disappearing from use in many households, and by one industrial establishment after the other in these cities and the surrounding districts, whilst the large steamers trading between the Weser and Elbe and Transatlantic countries, as well as the steamers of the German war navy at Wilhelmshaven, which formerly used almost exclusively British coal, have now taken to use the Westphalian article.

The important question regarding the comparative superiority of British and German coal has been settled in a decisive manner (at least from a German point of view) firstly, by a very careful testing of the qualities of the various sorts of Westphalian coal on the part of the Association of Coal Mine Proprietors, at Dortmund, in Westphalia; and secondly, by very minute and thoroughly scientific experiments made by competent persons under the supervision of the German naval authorities at Wilhelmshaven upon about thirty different sorts of Westphalian, and upon about as many varieties of English coal. The results of these investigations show that there are several kinds of Westphalian coal which in all essential points, are at least equal in quality to the best kinds of British coal, and that the former are in every respect as well adapted as the latter for any purpose for which the best kinds of coal may be required.

THE TELEPHONE IN GERMANY.

DR. STEPHAN, the enterprising Postmaster-General of the German Empire, who may be fairly said to have created the present international telegraphic system, appears to have definitely settled the question of the practicability of the general introduction of the new method. For the past few weeks the telephone has been in constant use between the General Post-Office and the General Telegraph Office in Berlin, and has superseded the telegraphic communication between Berlin and some of the neighbouring villages. The results have been so satisfactory that a few days since a consultation of leading telegraphic officials was held to make arrangements for the establishment of a large number of telephonic stations. Since the equipment of these stations is so inexpensive, and the long and costly preliminary training of a telegrapher is avoided, it can easily be understood with what readiness the new invention is put into practical use. Interesting in this connection is the recent adoption of the telephone by Prince Bismarck. He has, observes *Nature*, caused, as previously stated, the establishment of a telephonic means of communication between the Chancellor's office in Berlin and his country residence at Varzin, in Pomerania, 230 miles distant; and finds that he is perfectly able to give instructions and receive reports without leaving his favourite castle. No subterranean wires, but the ordinary telegraphic wires on poles, are used for this purpose. We should imagine that there is some mistake in this account of telephonic communication over a distance of 230 miles, and the subsequent examination leads England to decline its adoption.

STREET LAMP LIGHTING BY ELECTRICITY.

THE highly ingenious invention of Mr. St. George Lane-Fox for effecting instantaneous lamp-lighting, is now on view at the Fulham Works of the Horse-ferry Road Company (Gas Light & Coke Co.) It improves on what is familiar to us all when applied to separate huge buildings, such as Covent Garden, or the Hall at South Kensington : these we know are ignited at the meter, but such a mode would not be applicable to a large district.

Electricity claims recognition now as a power by which any number of lamps can be turned on, lighted, and turned off at pleasure. The lamps are connected together by insulated metallic wire conductors. An electric current is thereby generated at a given place, and made to operate simultaneously on every lamp by means of special apparatus attached to each. This ingenious piece of mechanism consists mainly of a soft iron core, around which is a coil of insulated wire, and is therefore a magnet, the wire of which forms part of an electric current connecting the lamps and forming itself a primary coil. Around this primary coil is a secondary, made of fine wire, and much longer. Here is an induction coil and a fixed magnet, which can render the poles reversible at will. Above this fixed magnet is a moveable one of permanent steel ; it is free to turn on a needle point forming a vertical axis, and thus develop when acted on a reciprocating horizontal motion.

These magnets are in a small metal frame that has a passage whereby the gas can pass to the burner at the top, and has a stop cock under the control of the reciprocating magnet. The entire apparatus is enclosed in an air-tight metallic case not three inches square, and is screwed on to the supply pipe in the lamp. The conductor is within the lamp post and underground usually, but not necessarily. The apparatus turns on the gas, and its other part lights it at the burner's point. An electric needle tap turns it on, and an induction coil lights it ; but both are in combination.

The plug of this needle-tap is cylindrical, about three-eighths of an inch in diameter, and is carried in a socket, which it fits rather loosely. It is made to turn in this socket, by the action of the reciprocating magnet, a couple of studs, on which are brought into contact a small pin connected with the plug, and forming, in fact, the handle of the stop-cock. The annular space between the plug and the socket—which is about the one-thousandth part of an inch—is filled with oil, which is retained by capillary attraction between the two surfaces, the joint being thus rendered perfectly gas-tight. The oil of bitter almonds is used, on account of its non-oxydizable character and from the power it possesses of resisting the action of very low temperature. Such is the apparatus designed by Mr. Fox, in which it will be seen that a very special feature is the introduction of a fixed core which can be magnetized so as to render its poles reversible at pleasure ; and, in conjunction with it, a movable magnet, the polarity of which, however, is permanent.

Assuming a group or series of gas-lamps to be connected by a conducting wire, the ends of the wire from this circuit are connected with a switch, which is simply a little piece of mechanism for placing the circuit in communication with, or disconnecting it from, the battery. An electric current is first sent through the circuit from an ordinary powerful telegraph battery. The result is that the soft iron core in each apparatus becomes converted into a temporary magnet, and the permanent reciprocating magnet above it is made to turn upon its axis. In performing a partial revolution the projections upon it engage with the pin or handle of the stop-cock, and turning that round open the cock and admit the gas to the burner. The battery is then disconnected from the circuit, and a condenser is charged by means of a Rumkorff coil, and then discharged through the circuit. The result is that an independent electric discharge is induced at the burner of every lamp at the same moment, and the gas is ignited by means of a pair of metallic points, which are connected with the secondary coil, and which deliver the spark. To extinguish the light the wires are reconnected with the battery by means of the switch, but in such a manner as that a reverse current is obtained. The permanent magnet of each lamp is thus caused to return to its normal position, and in so doing it again acts on the pin of the stop-cock and thus turns off the gas.

These experiments have been made during the past eight months incessantly, and many suggestions and improvements been made. Whether it is possible, or would be probable, to apply it to the street lamps of a large district remains at present quite an undetermined question. Sir William Thomson values it as of much probable utility in the management of lighthouses and fog signals at especial seasons. It is in any case of much importance to note every effort made in the way of human service by the application of science and art.

It is alleged to be capable of greatly decreasing parochial expenses, but there has been as yet no adequate experiment.

THE ART OF TANNING IN SOUTH AMERICA.

PROFESSOR Mr. Siewert contributes a mass of information on this subject to our contemporary, the *Journal of Applied Science* referring chiefly to the description of the materials used for the purpose in the Argentine Republic.

The tanning of heavy leather is one of the principal occupations of the northern provinces. It is a region that struggles under difficulties unknown in Europe, from the climate, which frequently putrifies the skins during the tanning process. It is necessary, therefore, to abridge to the utmost the period of the operations ; and in so doing the methods are rude and empirical. In Europe the tanners use the bark of the oak, but the oak is not indigenous in South America, and has not as yet been imported. The caob tree (*œpanish algarrobo*) which might be called the oak of the country from its slow growth and general aspect, unfortunately does not possess a bark rich in tannin.

Nevertheless, we have the cebil in two varieties—the red and the white—forming in the provinces of Tucuman, Salta, and Jujui, immense forests, which cover the mountain slopes to a considerable height. The bark of the red cebil contains more tannin than that of the oak, but it has the unsuitable property of giving a characteristic red colour to the hides, which, above all, appears when the tanning is completed and drying commences. This disadvantage having made it desirable to find a tanning material which will give the customary appearance to the skins, all the trees of our flora have been submitted to chemical analysis. I have separately investigated the wood, bark, and leaves, and the tables give an adequate idea of their tannic importance. I need not quote them, but I will add such descriptive and general information about those growths as seems necessary.

Red Cebil (Acacia Cebil, Gries.)—Experience, as well as chemical analysis, teaches us that the mature tree produces the greatest quantity of tannin, and that when the bark of old trees is used, the exterior layers, which are in general the hardest, should be rejected. I cannot affirm from my investigations that the trees of the plains contain more tannin than those of the mountains. The analysis not giving one constant result, I have been led to believe that the differences which have been frequently met with are all individual, and independent of the composition of the soil.

Experiments, the object of which was to isolate the tannin combined with the lime of the bark by boiling this with carbonate of soda, gave 1 per cent. of increase. The quantity of carbonate of soda was calculated from the weight of lime contained in the ash. It is remarkable that the wood holds no trace of tannin, whilst the leaves generally give one-half the quantity found in the bark.

White Cebil.—This tree is distinguished from the red species by its leaves, which are more finely feathered, and by the facility with which its bark dries and ceases to take part in the circulation of the tree. It therefore results that the tannic acid is very rapidly decomposed in the exterior of the bark, and becomes oxidised or else withdraws to the interior, according as the bark dries. The proportion of tannic acid contained in the exterior and interior parts of the bark is as one to ten.

The young trees of the two species of cebil contain almost the same quantity of tannin ; their wood contains a little, and the quantity in the leaves is somewhat superior to the half of that found in the bark of good quality.

White Quebracho (Aspidosperma Quebracho).—The trees which bear this name in the province of Cordoba do not belong to the same species as the white quebracho of Salta. I do not believe that the climate could cause a variety of this tree ; in my opinion they are different species. The leaves of the quebracho of Cordoba are armed at their extremities with small thorns, which (0·56 and 0·93 respectively) with the bark (5·84), even if it contained more, would not serve for tannin, because it is too thin and too difficult to separate from the trunk. The fruit, on the contrary, is rich in tannin, and although the seeds contain a very small quantity (12·03), the husks or shells contain 33·2 of pure tannin.

Algarrobo, black and white (*Prosopis Algarrobo*).— These two magnificent representatives of the Mimosa family thoroughly overspread our country. Unfortunately, in the populated districts they will soon disappear, on account of their slow growth, the small care taken of them, and the complete want of new plantations. The wood of the algarrobo is of extraordinary strength, therefore it is employed for all purposes.

It is not known why the designations, black and white, have been given to the two species. The flowers of both are white; the leaves of the black algarrobo are more finely feathered, and its fruit spotted with black and red is a little longer and narrower than that of the species called white, whose wood is dark brown, whilst that of the species called black is much lighter in colour and almost white in the young trees.

When the aged white algarrobo, with a trunk of more than a foot in diameter, is cut, a black and viscous liquid, bitter to taste, escapes from the vessels nearest the bark; it contains much tannic acid.

The leaves, the bark, and the wood of the two species of algarrobo are equally poor in tannin; they are therefore of no interest to tanners. Their economic importance is however great, not only on account of their magnificent timber, but also for the fruit, which is an excellent food for domestic animals and even for man. A glance at the following analysis will prove this assertion :—

	Fruit of Black Algarrobo.	Fruit of White Algarrobo.
Water	16·26	10·84
Fat	0·26	0·43
Sugar	37·63	25·21
Starch	11·24	16·71
Protein	7·37	10·25
Cellulose	11·79	
Organic acids, pectin and non-nitrogenous nutritive substances	14·20	23·31
Ash	1·25	2·03
	100·	100·

The sugar in the fruit is identical with that contained in the grape and the apple, consequently, it is very fermentable, therefore the country people make an alcoholic sparkling drink from the fruit after macerating it in water, which they call aloja. That of the black algarrobo is preferred for this purpose, and the fermentation is caused by the protein substances which it contains. Here is the composition of the ashes of these fruits :—

	Black Algarrobo.	White Algarrobo.
Silicate of lime	2·70	—
Silicate of potash.	—	5·84
Sulphate of lime	4·23	6·85
Phosphate of lime.	26·50	24·92
magnesia	—	8·70
Carbonate of lime.	5·14	—
„ magnesia	9·30	2·73
„ potash	7·11	31·05
Chlorate of potash	44·99	19·50
Oxide of iron	0·33	0·44
	100·	100·

The ashes, entirely destitute of soda, manifest such a large quantity of the salts of potash and of the phosphates as to prove that this fruit is clearly of great importance as food. In several districts of the country it is collected by the population, and forms their principal nourishment during the winter.

The algarrobillo, the wild walnut, the tipa, the coco or cochuchu (*Xanthoxylum Coco*), the tala (*Celtis Tala*), the lapacho (*Tecoma asper*, Gries.) the chanar (*Gourliaca decorticans*) and the cedar, are only of secondary importance to the tanner. We will make special mention, however, of the lecheron and the molles.

Lecheron.—In its leaves, its height, and its branches, this tree bears an external resemblance to the willow of Europe, and, like it, prefers a humid or marshy soil.

Its name, derived from *leche* (Spanish for milk), is due to its property, when a leaf or branch is cut or broken, on exuding a species of white sap, similar to the milky juice of the euphorbia. The leaves contain but one-third part of the tannic acid of the bark, and the wood is entirely destitute of it. Although the bark only contains 10 per cent. of tannin, it merits attention from its freedom from colour. The lecheron, moreover, has the advantage of being widely disseminated, and it grows much more rapidly than the cebil.

Molles.—In this country a number of trees and plants are designated by this name, although they bear no resemblance to each other, either in appearance of leaves, flowers, or fruit, and in reality belong to different families.

To distinguish them, a qualifying term is added to the generic name, such as molle for drinking, molle for tanning, molle for dyeing, &c. The "molle a biber," literally good for drinking, (*Lithræa Gilliesii*), is a handsome tree, found in the mountainous regions, which is utilised in different ways. The sweet and aromatic fruit is employed, as also an infusion of its leaves, in the manufacture of a refreshing drink, slightly alcoholic, a species of "aloja." The leaves contain 0·25 of colourless tannin: infused in water they serve as a black dye, and also to prepare a species of ink. Molle for dyeing and tanning is a species of *Duvana*. This variety contains more tanning than the preceding, and is used both for dyeing and for tanning. For this purpose the fruit is gathered before its maturity, when it is no larger than a grain of vetch.

The sprouts of a year old, despoiled of their leaves and fruit, do not contain more than 4·6 per cent. of tannic acid, whilst the leaves and fruit contain from 19·2 to 20. This variety of the tree does not exceed the height of twelve feet, and its leaves are very small. It is, therefore, difficult to procure large quantities; nevertheless, were the inhabitants to take the trouble to pick the leaves and the fruit from the dried branches, something could be made out of this rich tanning substance, especially in view of the fact that it is almost colourless.

TORPEDO WARFARE.

TORPEDOES are accounted by all civilized and uncivilized people to be the most unworthy form of inflicting injury. Robert Fulton, who invented them, had to contend against the instinctive objection of his contemporaries—that it was a mean proceeding unworthy of honourable combatants. And, even his amiable eloquence, aimed to seduce the Americans into his toils, failed. He told them that by torpedo boats "England's merchant vessels could be attacked, destroyed, and her trade ruined, and France could not be so much injured as at present. England who has usurped the dominion of the ocean, and laid all nations under contribution, would be the most humble supplicant for the liberty of the seas" and then the Emperor of the French would have a noble opportunity of displaying a magnanimity of soul," &c., &c., &c.,

This was in 1805, and a very pretty story ensued. America did not sufficiently remunerate or recognise the great engineer—for he was great—and he tried his fortune by applications to Pitt and Melville. Those Ministers declined to permit the introduction of such weapons into our catalogue of defensive or offensive weapons. So Fulton went to Napoleon, and prevailed on him to lend an old ship for the purpose of experiment. It was at Brest, and the torpedo blew the ship out of the water, and broke her back in the middle. Napoleon then permitted more elaborate experiments, for the purpose of attacking a British man-of-war. Great expense had to be incurred before the dread testing time came. When all things were ready, off went the torpedo boat, but the man-of-war also moved. The torpedo exploded amid the thundering satirical cheers of the British sailors, and all was over. Napoleon sent Fulton home, and the torpedo mania collapsed. The engineer told Pitt he could save half the cost of the navy; he told Bonaparte he could make France mistress of the seas. The inducements failed, and it was reserved for the period of the American civil war to witness the revival of a weapon that for half-a-century had been thrown aside.

The torpedo system dates from 1861, when the Confederate States adopted it in their contest with the North. As a matter of science, and as one of experience, we propose to offer the following statements, derived from the events of that strife, from those of the Franco-German war, and the varied tests which have occurred in this Eastern confusion.

Obstructions are a necessity. No country can afford to permit an enemy's fleet to sail straight into its harbours; and hence pile-driving just under average tide, rope-chains, and torpedoes have been introduced. But the regular fleet does not like them, for while they harass the enemy, they embarrass the defender. With fleet of sufficient strength there need be no resort to the questionable tactics; but a weak power or a weak point must resort to obstructions, and all the devices common to guerilla warfare or civic rebellion. The barricade, the ambush, and the torpedo are of one genus, and indispensable in many cases. They hinder, they make time, they worry and thereby weaken the foe; but they can never rank among the honourable weapons of attack or defence.

The best that can be said is that the torpedo occupies the same place in naval warfare as mines in land operations. They are of two kinds: one is effective from contact, the other from electrical action; but it is an essential point that the management be simple. The object of the torpedo is to sink a vessel, attempting to force a passage; which sinking, destroys a vessel, and creates an obstruction to a fleet. During the American war thousands of inventions were offered. Torpedo twin boats, propelled by rockets; driving apparatus, by which the torpedo could be attached to the bottom of a ship; balloons that would hover over a vessel and drop a torpedo on deck; rotation torpedo-rockets to be fired under water; submarine boats, with torpedoes attached to their spar—are but a sample of the unpractical schemes then brought to light because of the helplessness of the Southern States in naval warfare. Torpedoes became most effective weapons, but it was the simple and the cheap that won the day.

Those fastened to piles or other obstructions, or anchored so as to float at a given depth; or on land to hinder an assaulting column; or floating on the water, driving with wind and tide; or propelled by internal wheels, or attached to vessels, are among the most usual forms. These can be classified into those which self-explode on contact, and those worked from the shore; such as were many at Charleston in 1862. They are fired by the match, by acids, by percussion, by friction, and by electricity. Let us examine these more particularly.

Match-firing is not good in these days of snider rifles. It is highly dangerous; and with steam boats a quantity of loose gunpowder is too much of a risk on board a vessel—hence firing by acids. These are made of cast-iron attached, to a strong frame. A vial is filled with potassium, and another with sulphuric acid, well packed in cotton, and placed in a lead tube. Other arrangements, not necessary to be specified, are made, and the explosion apparatus is simple and reliable, by giving the torpedo three points of explosion the effect is certain.

There are those fired by percussion: but the construction is complicated, and the result problematical.

During the Confederate war the electrical torpedoes were first tried, and as they are the likeliest to become general, their early experience has some interest. One of the Federal gunboats was sunk at Charleston, and a description of the battery used is given here:—

"They were formed of nine zinc cups, each on shelves over the other. In each a porous-clay cup was placed, outside of which was the dilute sulphuric acid, and inside the porous cup was nitric acid. A clamp and thumb-screw connected the zinc of one cup with the cast-iron of the other. Negative wires led to the torpedoes; positive ran along the river-bank to the sub-battery, where were two large wooden plugs, with a hole of ½ in. diameter in each; these holes being filled with mercury, the positive wires from the charged batteries being inserted at the top of the plug to form connection and cause explosion. The wires from the river bank to the torpedoes were supported by a 3-in. rope being stopped to about every 4 feet rope. At a distance of every 15 feet, 5 or 6 ft. of ¼-link chain kept it from the bottom. These wires had a gutta-percha covering of ¼-in. thickness.

"The operator was concealed in a box of 4 ft. square, under the ground surface. He applied one of the wires leading through the plug to the charged wire, and the torpedo exploded.

"The direct magneto-electric current having been formed applicable for igniting gun-powder, or gun-cotton, other torpedoes were invented by which the ignition of the charge by an induction spark, instead of by wire, was effected, and also the torpedo by contact made self-exploding. These are technically known as the Austrian, which, although very effective, is certainly a very complicated mechanism. In fact all electric self-exploding contact torpedoes are so, and moreover are very costly. Their effect is not greater, and they are more likely to get out of order than are the friction-torpedoes, besides requiring extraordinary adroitness in their placement."

In connection with the subject of firing torpedoes, Professor Abel wrote an elaborate scientific paper which we cannot quote, but which any student should contrive to read. The patient description and careful detail make it—short as it is—an invaluable fragment of torpedo-construction and manipulation.

There are three systems among the many which are well known among naval engineers, especially the Abel-Maury, in which the exact positions of the sunken torpedoes is indicated by buoys, their azimuths taken, and marked on the horizontal circle of two telescopes placed at convenient stations. If the position of the torpedo does not change, the lines of sight of the telescopes will intersect at the spot where the torpedo has been sunk so soon as the index points. The telescopes are connected with each other, and with the torpedo by a cable connected with a battery and with keys. Each observer, keeping his key depressed, follows with telescope the movements of the enemy's vessel. The explosion occurs when the circuit is closed; that is, when the vessel has arrived over a torpedo. There is much detail, but the reader will gain a general idea from this sketch.

We heard what these weapons did. It is painful to read the reports sent to Washington. Vessel after vessel met with destruction by these means, and indeed such means were the only available defence the Confederate party could obtain. They were means the Federals little dreamt could be made available, and dozens of their ships went to the bottom by their agency.

The laying of torpedoes, as we shall see in our notes on the present use on the Danube, is an operation requiring much care, especially where the self-exploding contact-torpedoes are concerned, for there is a great risk of premature explosion. They are provided with safety-guards, but it is not every one who knows how to use them. In the American war one curious fellow wanted to know what the machine was made of, and unscrewed the guard; in a second, explosion after explosion ensued and he was mortally wounded, the mules killed, the whole place splintered into shreds, and a mischievous ruin all around.

We will now notice the existent conditions as derived from the current experience in the East.

The attention of the Turks was drawn first to the employment of torpedoes as a means for the protection of the Bosphorus and Dardanelles. With the aid of a few European officers, a series of experiments was carried out to ascertain the effect of torpedo explosion in a strong current, and to discover the best means of mooring submarine mines. A spot was selected close to the mouth of the Bosphorus, where the current is strongest, running at an average speed of five knots, and here, in 40 fathoms of water, and floating within six fathoms of the surface, a torpedo was moored. It was a cylindrical-shaped cone of thin sheet iron, contained 600 lb. of large-grain powder, secured to two large sinkers by chains, necessary buoyancy to bring it to the desired position below the surface of the water being obtained by means of a raft. On exploding it threw up a vast mass of water, and the force exerted would probably have sunk the largest vessels. In height the dome of water must have been upwards of 100 ft., the diameter of the base 200 ft. The shock was felt forcibly on board a tug situated a mile distant. This was followed by another experiment with a torpedo of the same dimensions in the presence of the present Sultan, off the Prince's Island in the Sea of Marmora, the torpedo on this occasion being floated within four fathoms of the surface. An old wooden steamer was placed, and at a signal from His Majesty, the vessel was blown up, the last fragments of the broken wreck disappearing in about ten minutes after the explosion. This decided them, they passed from a state of inactivity into energy. The Arsenal was busy day and night rolling plates, and resounded with the din of cutting, punching, and riveting. The Turkish torpedoes are of two kinds, electrical and contact. The former, of different sizes, are made of boiler plate, cylindrical in form, of two-eighths of an inch of iron at the sides, and three-eighths of an inch at the top and bottom, the requisite buoyancy being obtained by a thin partition called technically a diaphragm. In one of these partitions is the powder, while the other not only gives buoyancy, but also admits of the expansion of the gas requisite to insure the ignition of the whole charge of powder before the case bursts. As gun-cotton cannot be procured, a large grain-powder of excellent quality is used, which is manufactured at the Imperial Mills, outside Constantinople. A few, however, of the first placed were fitted with guncotton, which happened to be in store at Constantinople at the outbreak of the war. The fuzees consist of a piece of very fine platinum wire placed between the ends of the conductors. This is much the same as those used in our own service with electrical batteries. But the Turkish fuze, a small piece of carbon, which becomes incandescent by the passage of electricity, which is placed in the centre of the platinum bridge by the wire being passed round it once or twice before being secured to the ends of the battery wires. The Batteries are Le Clanches, of the newest type, wherein manganese and charcoal surrounding the carbone plate, which forms the positive pole, and are compressed together into a solid mass. The circuit closer system has not been adopted for either the Bosphorus or the Dardanelles. From the great and varying strength of the current, it would have been impossible to insure the "closers" always being at the proper depth; and secondly, sufficient experience had not been acquired as to the action of these instruments in a heavy sea, which is often met with in the Bosphorus and Dardanelles with certain winds. The method adopted for firing them is by observation from two stations. Every one knows something of electricity, and is aware that what is called the "electric circuit" must be complete before the requisite passage of electricity which is to

inflame the fuze and explode the torpedo occur. The battery and the fuze form part of this circuit, and a double wire may either be used to connect them, or the sea itself can be made to serve the purpose of one of the wires, and thus effect a great saving of wire. In ordinary circumstances, then, there is always a break left in this circuit, and it is the closing of this break which produces the explosion at the moment required. With the circuit-closer this is brought about by the vessel which it is intended to destroy ; herself closing the breach ; and there is thus no risk of a premature or late explosion. When circuit-closers are not used, then, in order to insure the explosion of the torpedo at the right moment, two breaks in the "circuit" are arranged, one at the battery and one at a second station, being the end of the base line, considering this point, the battery, and the torpedo to form a triangle. As each torpedo is being placed its direction is taken by a line of sight from each station, and so later on, when an enemy's ship appears, all that is required is for the observer at the second station to close the break when she is passing any one of his lines of sight, while the observer at the battery closes the break of the particular torpedo wire corresponding to the line of sight at his end of the base which the ship may be passing. Unless these two breaks are simultaneously closed there can be no explosion, and this can only happen when the ship is passing an alignment at each station, showing that she is over a torpedo and favourably situated for blowing up. These alignments are taken with instruments suitably arranged with telescopes and screws for the torpedoes. The telescopes carry long arms connected with the battery, which touch the ends of each torpedo wire as the vessel passes a line of sight, and so closes the break.

Besides these instruments there is Siemens' Indicator. Two stations are chosen, from which a clear view of the ground to be defended can be obtained. At the one there is a table large enough to hold a good large sheet of paper, on which the positions of the torpedoes are to be laid down as they are placed by the mooring lighters, and at the other an electro-magnetic machine. The table at one end of it has a telescope fixed upon a pedestal capable of horizontal motion, and by means of a pointer which it carries the direction of the telescope is projected on the paper. At the other end of the table, or at some slight distance from the telescope and stand, there is another pointer made of the very lightest material possible, which is connected to machinery in the small box underneath the table. This machinery is set in motion by currents of electricity sent from the electro-magnetic machine at No. 2 station. At this No. 2 station—which the foregoing will have implied is connected with No. 1 station by an electric cable—there is also a telescope fixed on the top of the magnetic machine, and it is so arranged that the turning of a handle will not only move the telescope but cause the induction of currents of electricity. As each torpedo is being laid the observers at the stations, by preconcerted signals, bring the torpedo into the field of their respective glasses, upon which the two pointers will be found to cross over the paper on the table, for, just in the same manner as the hand moves round the dial plate of the telegraphic machine used in banks and large establishments indicating the signals transmited from other departments, so the pointer on the table moves in a direction precisely parallel to the telescope at No. 2 station. The other pointer moves also in the same manner as the telescope at No. 1 station, and thus there are two similar triangles of which the base lines are the distance between the two stations of the one and the short space between the two pointers at the table of the other. Each torpedo is observed in the same way, and the points of intersection being marked, a perfect chart of the harbour and the position of its torpedoes is easily projected. The wire of each separate torpedo is brought into a table near the battery, and there secured to what is called a firing key, an instrument permitting of rapid connexion with the firing batteries. All that is now required is for two intelligent observers to watch the motion of the enemy's ships, while a third, with his eyes on the chart and his hands hovering over the keys, watches the motion of the pointers, and the moment he sees that the point of intersection coincides with any one of the numbers marking the position of the torpedoes, he fires that particular one, knowing that the ship must be over it.

The first experiment made by the Turks to pick up torpedoes was by means of a kind of anchor, four-pronged, called a grapnel, with a double stock as a guide for the ring, to which was attached a length of small chain, and to this chain a threequarter inch rope of the best hemp. The ring and stock were covered with indiarubber. The anchor, or grapnel, was fired from a small mortar 4in. in diameter, with a charge of 100 yards, carrying the line with it. In order to make the anchor fit the bore and attain the proper range a half-shell was fitted to the crown of the anchor and pieces of wood placed round the stock and secured by a thin band of copper. The ring lay on the top of this wood, and was of course outside the muzzle of the mortar. The explosion breaks away the wood, and the anchor flies forward, while the indiarubber prevents the snapping of the chain. The idea is to fire the anchor over the supposed site of the torpedoes, and then haul them up, cut the wires, or sink the torpedo by firing into it with guns, or even muskets. To counter-mine is another method the Turks intend to adopt, which simply means to torpedo the torpedoes themselves. In the dark, or under cover of the guns of a ship, a boat is to pull in to the supposed site of the torpedoes and sink another. It is calcuated that 500lb. of powder so exploded would explode every other torpedo within 200 yards, thus opening a passage for the ships. If, however, the enemy fires his torpedoes when he sees the boats over them he equally opens a channel. The Turks have no self-acting electricity-driven launches to perform this operation such as are in use in England.

The third, and last, system as elaborated by the Torpedo Staff of the Admiralty seems an excellent plan. It consists in "sweeping" for the torpedoes. First comes a line of small boats "creeping" with grapnels ; then a line of steam launches sweeping the ground with telegraph wire, which is strong and flexible, and then a couple of tugs with a hawser between them, with grapnels suspended. If any of the boats hook anything like the wire it is cut, and the torpedo rendered harmless, or they may succeed in dragging it up sufficiently near the surface to be able to destroy it. If the torpedoes are of the "contact" description great care is required, and the boats when they hook anything, or when the sweeping line meets with an obstruction, cross each other's bows, and thus bring the line round the torpedo, and then, by pulling or steaming away as hard as possible, endeavour to explode it.

Two lessons may be said to have been learnt from the war as as far as it has gone which are particularly instructive and to a certain extent satisfactory to us as a maritime Power. The first is that a naval supremacy is not imperilled, much less entirely destroyed, by the use of torpedoes, if all the methods of attack and defence are adopted, and if every vessel has all the offensive and defensive appliances. "Thornycrofts" can be met with "Thornycrofts," and "Whiteheads" can be launched as well from the ships of one nation as of another. Numerical strength, discipline, and drill, with courage and ability, will still give the command of the sea to those who know how to hold it, and anything that could ever have been done by a fleet can be done again. It is absurd to listen to the timorous cackling of alarmists who cry out that the invention of torpedoes has struck a deathblow at our supremacy at sea. I believe myself it has done nothing of the kind. It has, however, somewhat changed the mode of warfare, and it is absolutely necessary for us to strain every nerve and to do our utmost to be first in this race. The second lesson is that a nation with an undoubted supremacy at sea, as is undeniably the case of the Turks in the Black Sea, cannot neglect submarine mining as a mode of defending her harbours, trusting to her fleet to perform this duty, nor must she rest in the false sense and security, as I remarked before, that torpedoes alone can protect them. Thus again, though torpedoes may greatly assist the ships in the defence of the coasts, they cannot do it alone, but with a few light guns behind them, sufficient to prevent boats and light-draught vessels destroying them or picking them up, they are of the greatest value. The conviction, however, is now forced on naval and military men that torpedoes as a sole means of defence in exposed roadsteads, such as the Firth of Forth or the Clyde, are practically useless. Without the aid of batteries on land or a guardship to protect them moored inside the lines of torpedoes, there is nothing to prevent attempts being made to remove, destroy, or explode them.

STEAM TREE-FELLING MACHINE.

TREE-FELLING has been long the study of mechanical engineers, epecially in America, where, when the soil is to be cleared, it is best to do it quickly. Several patents for machines have been taken out by inventors there, but none have been successful. That we illustrate is the production of Messrs. Ransome & Co., of Stanley Works, King's Road, Chelsea, and has just been put to the test of action in the South of London, at Tulse Hill, on the Roupell Estate. There is a kind of resemblance to that patented in America fifteen years ago, but there is this essential difference,—*that* could not do its work ; and

this can and does. The trial referred to proved its excellence and efficiency.

We will merely recite the method of its working, the illustrations show its form. There is a horizontal steam cylinder, 4½ ft. diameter, and 20 in. stroke, which is carried by a vertical solid trunnion on a cast iron bed-plate, and is supplied with a 3-horse portable boiler through a proper hose. The slide-valve works at right angles to the cylinder, and is put in motion by a flat twisted bar, such as is used in Messrs Merryweather's fire-engines. The cross-head of the piston is guided by two round rods. To the cross-head is fixed a heavy saw-blade, and two holes in the end of the saw drop on two pins, a top piece is put over and screwed down. The saw is permitted a certain amount of slack to ease it in its work. Its teeth are very large and much hooked, so that it cuts only when pulled by the steam piston.

Close to the tree to be felled an excavation of the depth of a few inches is made, in order to clear the bed of earth and gravel: the bed-plate is then placed in the excavation, and is secured to the tree by the claws, which are set up tight by a hand-wheel and draw-screw at the end of the bed-plate. Thus the cylinder and saw are free to revolve in a horizontal place on the vertical traunion, by the motion communicated by the hand-wheel, endless screw, and are at the hinder end of the cylinder. The saw is thus brought up to the tree, steam is turned on and the work of felling begins: a piece of board at the outer end of the saw on the ground supports the saw.

The business is not long. About fifteen minutes is enough to prepare, do, and get away: the cutting itself not requiring more than 5 minutes and a half for a tree 2 ft, 3 in, diameter. In the case referred to a 4-horse portable engine was employed; and with a pressure of about 70 lbs., the saw made from 250 to 300 strokes a minute, that is to say 125 to 150 cutting strokes; at this experimental incident, six trees were cut, four of 3 ft. diameter and two 2 ft. 3 in. all within one hour.

Criticism suggests a difficulty from the great care required in its working, but admits that its actual work leaves nothing to be desired. These difficulties are thus defined. It takes four men to carry it from tree to tree because of its weight; and when it is at work one man must attend to it, and another man is required to look after the boiler.

These are inevitable difficulties; a man does not suppose that a 9 ft. tree is to be cut down with a pocket knife, or expect that the instrument will put itself in the proper place. Still less will he look for a supernatural intelligence in a steam engine and boiler. We have not lost our rationality so far as to calculate on impossibilities, nor have we yet learned that our defective intelligence has been rebuked by the superior endowment of iron machines with the especial attributes of man.

Another difficulty is stated, as consisting in the fact that from almost the moment the saw begins to work, a guy rope must be employed to draw the tree away from the cut side, for if this be not done the saw is bound and may be broken; and that this operation takes the strength of several men. This is the very extreme of criticism. You cannot use a bent saw through a 4-in. log without something of the kind, unless the saw teeth are set so wide as to be in imminent danger of being every one broken; and surely a guide rope is necessary in all tree felling. What would a jury say at an inquest on a man killed by the falling of a tree in an unexpected direction? they would assuredly expose the owner to a charge of manslaughter. We maintain that the machine is a great success, and will be of immense service in those regions where forests have to be dismantled, and virgin ground cleared for cultivation.

THE CHEMISTRY OF PAPER MAKING.

PAPER MAKING formed the subject of an article in the Practical Magazine (Vol. V,) in which the machinery rather than the chemistry of the art is described. Every month has in its course some new description affecting details, and in some cases even the principle. The vast works that have been erected in England, Belgium, and Scotland, during the past ten years, and which are gradually being made more effective and more perfect, as old machines wear out and new inventions are introduced, make it almost necessary to retrace the whole history in these decennial periods. Mr. Thomas Wrigley of Bury; and Mr. M'Murray of Wandsworth; the Ford Works of Sunderland; Mr. Collins of Hull, and others in England; Messrs. Cowan & Co., and Mr. Todd, in Scotland, are some of the most conspicuous in the catalogue of enterprising makers who eagerly seize every invention that can lower cost, improve quality, and facilitate production. It is a race that wearies the weak, but remunerates the capitalist. We described a fine machine erected by Messrs. Bertram of Edinburgh for Messrs. Robert Craig & Co., Glasgow, in these columns a few months ago, and that is at present the best known. No more need, therefore, be said about machinery, and we turn to the delineation of the chemical processes.

These are multiplying at a profusion defying detailed description: in fact, details of that kind are, when they become public, superseded by others which are carefully concealed for as long a time as possible. Many mills have their own chemists, and these have, as before stated, every motive to do "their quiet best" in their own particular works, and avoid all disclosures likely to affect their professional supremacy.

Mr. Routledge, who combines the chemist and manufacturer at the Ford Works, Sunderland, is the highest authority in the treatment of vegetable fibres, which are continually increasing in variety and quantity, and in September the *Practical Magazine* contained a minute statement as to the processes he recommended for treating bamboo and other Indian growths; to that the reader is referred, rather than that the method shall be recapitulated here. And the purely chemical terms shall be avoided or explained, for it is not possible to convey to general readers even of scientific works so intelligible an idea by their use as by a more diffuse but popular method.

Unsized paper is said to be pure cellulose—that is to say, the essential part of the solid framework of plants. The cell-walls in the early stages of their development are composed entirely of it, but as the plant grows they become incrusted with colouring matter, resins, and other foreign substances. The pith of the rice-paper plant is entirely of this substance, a portion of seeds of vegetable ivory and other trees contains it, and manufactured vegetable fabrics,—cotton, hemp, linen, and as just stated, unsized paper, have it pure.

The easiest way to obtain it is to wash white cotton, unsized paper, old linen, or elder pith, with a hot solution of caustic potash or soda, then with cold dilute hydro-chloric acid, then with ammonia, washing thoroughly with water after the application of each of these re-agents, and lastly with alcohol and ether; it is often necessary to repeat this series of operations several times. In obtaining this substance from wood it is necessary after boiling the wood with potash, till the liquid is almost dry, to treat it with chlorine-water, or with a weak solution of chloride of lime, repeating the operations several times in order to free the cellular tissue from the encrusting matter. The vegetable fibres in the excrements of herbivorous animals furnish a convenient source of this substance, because digestion has done for it what chemistry has to effect by elaborate processes. This excremental material is largely used in Belgium and Sweden in the manufacture of boards resembling mill-boards, and used for cloth and account book bindings in its crude state—when purified it yields fine paper-making material, white, insoluble in water, alcohol, ether or oils, and remains pure after exposure to the air. When it is taken from wood it gradually decomposes in moist air, and the result is touchwood.

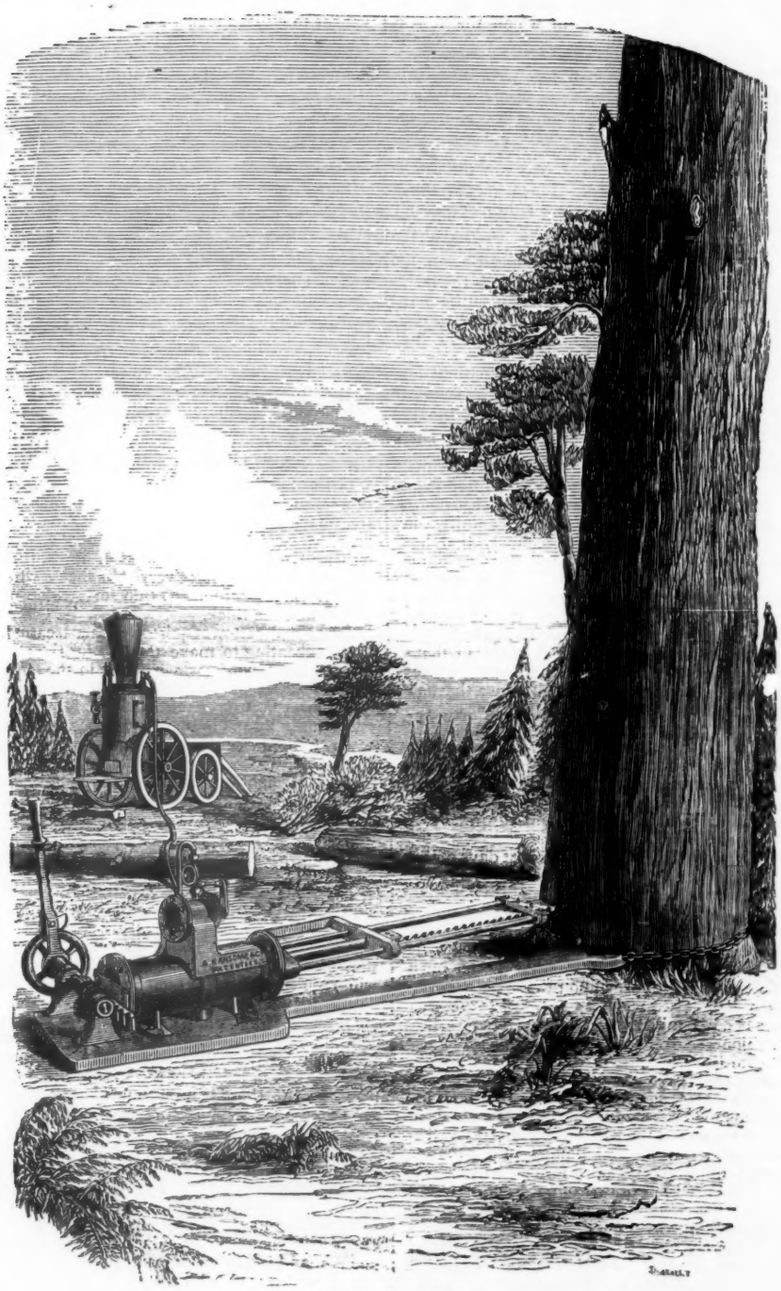
Sulphuric acid is a great advantage to the paper maker. Unsized paper—that is equivalent to cellulose plunged for a few seconds into sulphuric acid diluted with half to a quarter its bulk of water, and then washed with weak ammonia, undergoes a very remarkable alteration, being converted, without change of composition, into a tough substance very much resembling animal parchment, and applicable to the same purposes. This product is called *Papyrin* by the discoverers Messrs Poumarède and Figuier in 1847. Those gentlemen made no use of their invention, and an English patent was taken out by Mr. Gaine ten years afterwards, and is largely used for all the purposes of parchment deeds, drumheads, coverings for preserve pots, shirt collars, imitative lace, paper curtains, &c. Gaine succeeded by diluting the sulphuric acid to half the strength of that employed by his predecessor.

But by the use of strong sulphuric acid or phosphoric acid this substance cellulose can be converted into dextrine which is like unto starch, soluble in water and is applied to a variety of useful purposes; it may indeed be used in almost all cases in place of gum arabic. It is employed for stiffening calicoes, for the sizing of paper, and for the adhesive layer at the back of postage stamps.

This dextrine is said to be isomeric with cellulose; that is, both are made from one substance, and in equal ratio, but have different chemical qualities through a varied treatment.

Linen cellulose when boiled for a short time with moderately dilute sulphuric or nitric acid is converted into a pulpy mass that retains its original composition, but does not sensibly dissolve in water.

Before dismissing this part of paper material we will notice



TREE-FELLING.

the treatment adopted for making waterproof paper and what is called Japan paper, used for reticule bags, in imitation of leather.

When linen rags, or wood saw-dust are fully dissolved in ammoniacal copper solution and the solution then allowed to evaporate to dryness, a semi-transparent brittle glass is left. But if the action of the solvent be prevented from effecting more than a commencing superficial solution, in which the fibres maintain their original form and disposition, a very tough material is obtained. A sheet of paper, left only an instant in the ammoniacal copper solution, and then passed between rollers and dried, becomes quite impervious to water, and does not lose its power of cohesion at boiling heat. Two sheets of paper thus treated adhere firmly together and form one piece (called in the trade couching, or, "the paper is couched"); and by treating a large number of sheets of paper in the same manner, artificial boards are produced. Linen pieces thus treated furnish a very elastic material of great cohesive power. By treating linen and paper together in this manner, a material is obtained of great firmness and strength. In the case of reticule bag-paper (Japan paper), the black colour is produced instantly by *Fluoride of boron*, and the embossing machine does the rest.

One of the greatest difficulties in paper manufacture has been the obtaining of pure white colour without weakening the fabric of the paper. Bleaching has generally injured the strength. Lime was used freely in old time, and patents existed in reference to such application of so simple and natural an ingredient, but modern chemistry has shown that caustic soda or potash affects the cellulose but very slightly when it is properly employed. If unwisely dealt with it is ten times more destructive than any other chemical. The fibre needs cleansing, and the agent must not be permitted to affect that fibre whilst removing the foreign substance; or at least whilst producing uniformity of material, must not reduce the average of strength for the sake of colour. The coarser materials can be utilized in many ways because they are strong, but the economy that has endeavoured to make pure paper out of coarse rags or fibres has ended in absolute ruin, and deservedly. That method requires more artifice than a chemist will supply, and costs more money, by its uncertainty and disappointments and chicanery, than can be recovered when the product comes to market.

Fibres and their treatment is the essential study in these times. Rag is pretty well understood, but not perfectly. Fibres invite the attention of the experimental chemist, because, that notwithstanding the progress made there is much to learn, even in the fibres already worked; and an unknown land is that of the marvels which India and Africa have in store for the paper-maker's chemist, when the products are brought over and duly analysed. A half-hundred inventions relating to straw, esparto wood, grass, flax, cotton-waste, witness not to the ingenuity of the departing generation, for they do not go beyond the principles enunciated by the Bermondsey paper-maker who first converted straw into writings and printings in the very earliest days of this century. That was a most simple process, and the ingredient common lime. All the mysteries since invented turn on that, and derive all their exclusive virtue from modern chemical combinations that are not inventions at all. We must look more to the machinery. The careful treatment of the stuff by the chemist's art is understood to be indispensable and most profitable, but the final advantage turns upon the wise application of machinery, especially as to boilers.

For instance, there is one familiar to paper-makers, not only from the skilled practitioners, Mr. Routledge, of Sunderland, and the two brothers Richardson, of Jarrow, but from the candid manner in which they stated their method. It is a matter of detail, but contains much that is suggestive. Waste liquors, resulting from the preparations of fibrous substances, contain valuable ingredients that can be recovered by purification and evaporation. This is the mode: run the hot liquors into pans or reservoirs, and evaporate in a reverberatory furnace to burn off the organic matter. When red-hot draw from the furnace and expose to the air; if carbon remains reheat in a carbonating furnace until white ash is obtained. Sometimes, instead, perhaps the organic matter is merely charred and therefore insoluble, the residue being digested in water, and the solution is boiled down to dryness or *mixed with lime* for subsequent treatment.

These ashes are mixed with quick lime, ground together, heated in a furnace until all the acids are evolved, or the ash is dissolved in the water, and the lime slackened with the solution. The result is lixiviated in water, and the liquor obtained is useful. These operations are in general conducted in common pans or furnaces, or in a furnace of "two beds" separated by a bridge, the one nearest the fire being devoted to the treatment of the material with lime, and the other for burning the organic matter. These bridges are hollow with openings to admit air. At the end of the furnace is a pan built to allow the combusted products to pass over the liquid with which it is filled. Above is an iron pan, and the combustion products pass beneath through a flue, and thence over the liquor into it; and above is a third pan or reservoir into which the waste liquors may be run.

These waste liquors are acquiring commercial and manufacturing importance. By law they must not now be sent down stream; and that prohibition has been the cause of many contrivances to utilize them. These are many, and they need not be particularised; sufficient is said when noting that the work of the chemist concerning them is not yet ended. There is a large field still unexplored in the utilizing of manufacturing waste, of which these liquors are not the least important. Some are derived from the treatment of straw, some from esparto, some from rags, and each of these differ not only in their origin, but in what they collect in the operation of cooking from the substances treated.

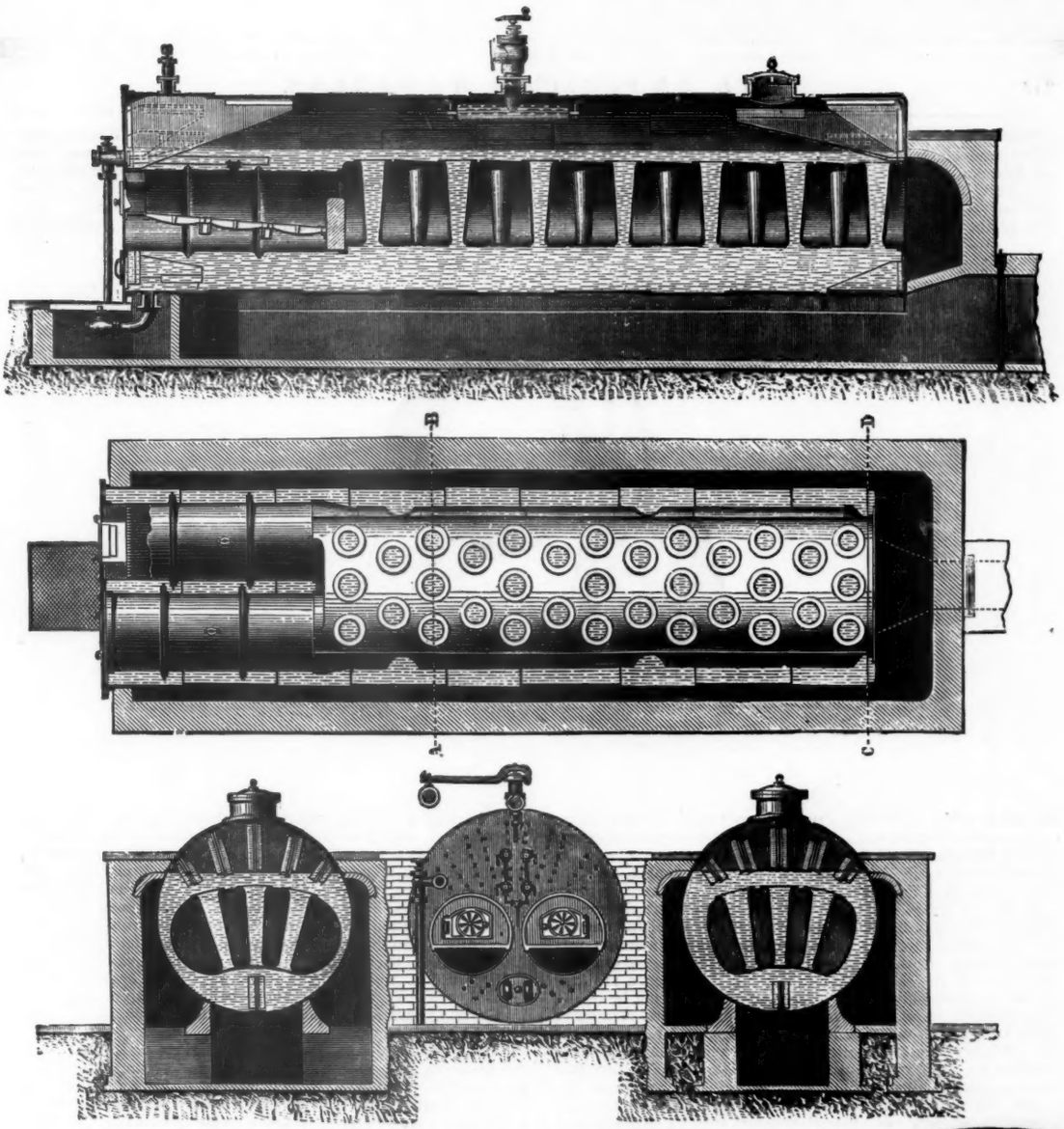
Paper pulp differs in its very nature according to these substances. The short, hard, smooth straw yields a very different result to esparto,—that fine fibrous starchy grass, every blade of which can be separated by hand into twenty silken lines, and in the machine is equal—except in strength—to rag. The straw is harsh, and will not curl, no chemical can overcome its obstinacy; but it gives good surface when properly managed, and chemistry has purified its colour. Bleaching does not weaken it, for it has no strength in any case. Straw is cured by lime and some caustic soda. Esparto has the property of curling similar to rag. When "beaten" the particles are attracted to each other, and twist themselves about each other, making a substance that will not easily tear, whereas straw is always short and inclined to crack and break. The esparto stem or blade, if four feet in length, can, as we said, be split by hand its entire length without breaking, and each piece can be tied with knots without breaking, just as cotton fibres might. It is also of a nature that needs not strong bleaching, nor indeed harsh treatment of any kind. The paper made from it has a most excellent surface for smoothness, and although not of the strength either of cotton and still less of linen, it is sufficiently strong and can be made into very thin sheets without any risk. On the contrary, we think the thin sorts to be of better quality and finish than the thick.

Linen and cotton require no other treatment than the bleaching and beating to make them fit for the vat. Steeping, washing, getting rid of former colour in the case of coloured rags, are operations so simple as not to require any notice. Linen is the most perfect of all materials for making paper; of it the bank notes are made by Messrs. Portal, of Hampshire, and the water-marked continental commercial documents by Mr. Barsham Green, near Maidstone. Such paper will not break if a 56 pound weight is attached to a suspended sheet, and little or no chemistry is required. Steeping and washing is enough; the very finest specimens of paper ought not to be absolutely white, they should be cream-coloured by nature, not by art, and this tint will be the natural outcome of paper made, say, of Government white canvas and duck.

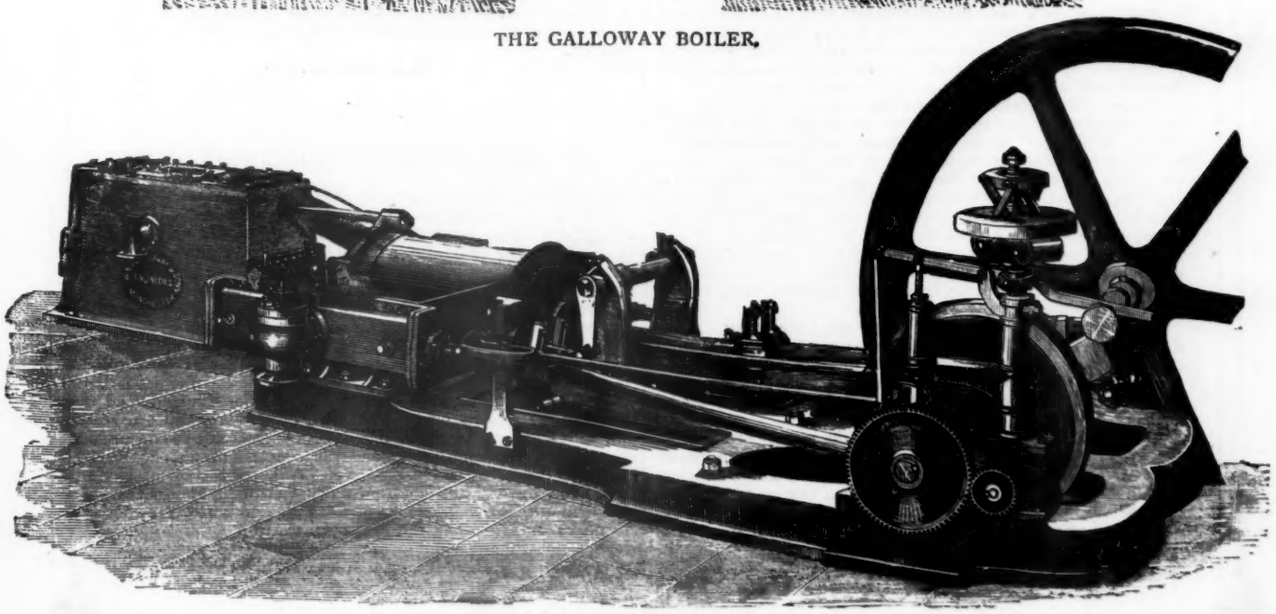
These materials, however, maintain a price that forbids their general use; and at the high price they are scarce, and more likely to rise in value than otherwise. The trade anxiously looks for substitutes, and as we have had occasion to notice in this and previous numbers, other materials are being introduced that will require the art of the chemist in novel forms before they can find a substantial position in the market.

Of the sundry materials little requires to be said. The beautiful Manilla fibre is almost gone from the hands of the paper-maker into those of the manufacturer of textile fabrics. Of three and four feet in length, of the softness of silk, and the strength of best twine, there is no wonder that better uses were reserved for it than the manufacture of Emery paper and fine drapers' cartridges. A sheet of it unbleached is of a light-brown colour, and can be crumpled up as one would a pocket handkerchief, and if perfectly made it could not be fairly torn or broken. The American market had a very good substitute, but that has also gone. Japan holds it still, and as their trade increases, the probabilities of its export diminish every day. That required no chemistry whatever; washing, beating, and boiling were quite enough, and it has this advantage: esparto or cotton will work with it, which is not the case with its kinsman, jute; that which looks so likely to accept the same treatment is exactly opposite. It is shorter than straw, although it looks as pliable as manilla. Tie it into a knot and it will break instantly. And jute again will not work with any thing else. What bleaches all others darkens it; what bleaches it darkens all others. But jute has gone to the silk market for manufacturing spurious silks and cheap haberdashery.

Wood is usually cut up into small pieces, then beaten and boiled, but it is a troublesome material, not only from its substance, but from its stubborness and foulness.

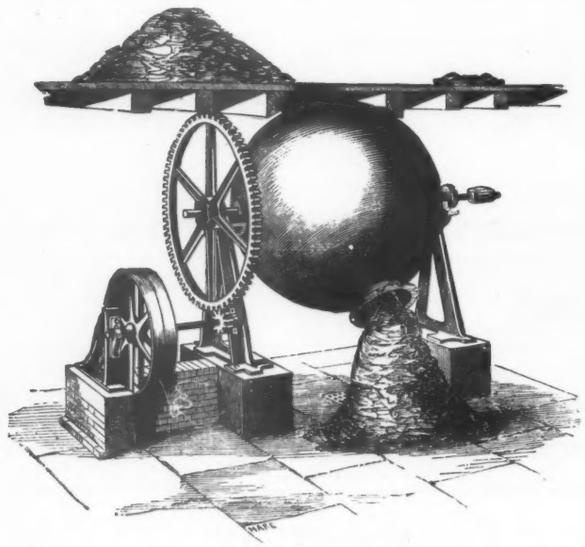


THE GALLOWAY BOILER.



THE GALLOWAY ENGINE.

Messrs. Donkin are well known as the pioneers in paper-making machinery. It was their house that brought out the first paper-making machine, and the position then attained has not been abrogated. The illustration of their spherical boiler tells its own tale. Being spherical it is twice as strong as a cylindrical one of the same diameter and thickness. The plates are of the usual substance, which makes it perfectly safe, durable, and suitable for high pressure steam. The contents, as is seen, falls out of itself when the boiler is revolving with the cover off. Inside are strainers to take away the dirt, and lifters to agitate the rags during the process of either boiling or washing. This boiler is almost universally employed for rag boiling, but is good



for other work, with this caution: so tender a material as esparto needs not the cuffing about which woven goods require; but on the other hand it is a very expeditious mode, and its operation can easily be made less violent and more brief, in order to preserve the the texture of the fibre.

Stationary boilers are made of cast-iron and malleable boiler plates, and they are taking the place of the revolving ones in all large works. In the beginning of this notice, mention was made of large works, but those of Dartford Creek were omitted. The *Daily Telegraph* proprietors turn out from thence 110 tons a-week of news only, and revolving boilers would not be of the least service to them. In mixed mills, such as Messrs. Wrigley of Bury, Lancashire, where writings, printings, and news are produced Messrs Galloway's boiler is the one that rules the machinery; and that we will now attempt to describe for, not only has that firm the endorsement of many first-rate paper-makers, but that of all other steam-users, whereby they have become the largest producers of manufacturing steam engines and boilers in England, since more than twenty years ago, at the Great Exhibition, their work was tested, and has had the hearty recognition of one who never wastes his praises, Mr. John Bourne, than whom there is no like capable judge.

There is this difference between the fortunate American and the successful "Galloway." In the former the large internal fire-flue or flame chamber is occupied by a great number of parallel tubes, about 2 in. in diameter and 5 feet long, placed vertically, and connecting the upper and lower portions of the water chamber. Through these tubes the water circulates very rapidly, and forms a most effectual means of warming a large quantity of water in a short time and with economy. In the "Galloway" boiler the space behind the furnace is occupied by a smaller number of *taper* or *conical* tubes, of 5 or 6 in. in diameter at the upper end; it therefore requires more length and less in depth than the other.

This making the upper part larger than the lower is the distinctive mark of Galloway's house—their trade mark. By that construction priming is avoided, and the flame acts more effectively against the sides of the tubes, thus preventing their being injured by overheating and burning out at their upper ends.

Boilers on this principle became all the rage. The Gutta-Percha Company, and many other factories, the large paper mills in the north, and some of the largest in the south, adopted them as soon as circumstances permitted a change to be made in their works. One of the boilers erected in London by R. Armstrong was capable of evaporating a cubic foot of water a minute with only about 6 lbs. of common bituminous coal every hour, while driving a 30-horse condensing engine indicating 50 h.p. besides supplying steam for other purposes. This unprecedented degree of economy could scarcely be believed. The size of this boiler was, length, 30 ft. 3 in. diameter; of inside, 7 feet; greatest diameter of main flue, 4 ft., 6 in. inside, by 3 ft. deep, containing 13 conical water tubes, each 11 in. inside diameter at top, and 9 in. at bottom, which tubes acted as prop-stays between the flat top and bottom of this main flue. The entrance to this main flue is by two parallel and similar furnace tubes, each 8 ft. long, and somewhat oval in section, being 2 ft. 6 in. wide, by 2 ft. 9 in. deep. This oval shape increases their strength on account of containing three strong cast iron bearing bars for supporting the grate, which act as prop-stays from side to side.

This kind of boiler has had the very highest praise that could be rendered, and in the great public undertakings, here and abroad, state patronage. Other makers make good ones and are full of orders, but in a general notice of boilers it is almost a necessity that reference be made to the indisputable, in order to avoid any expression of favouritism which is most certainly not felt.

To be continued.

IRON AND STEEL PRODUCTION.

RECENT documents on these subjects are of sufficient importance to claim the attention of every intelligent observer of the course of manufacture and trade. The unparalleled depression that has continued unusually long is without relief, and as yet without hope. Blame is freely cast on the producers for having glutted the market, but such reproach may easily become unjust. The causes are numerous and complicated to a degree that almost prohibits discussion, but there are two which are practically uncontrollable; namely, bad harvests, and the state of the labour market. The first will right itself, but the second is not so easily disposed of. Agriculture in England and America is remunerative: manufacture here, there, and everywhere is terribly profitless. The iron and steel trade has undergone statistical examination, and the conclusions and figures demand careful attention. A New York correspondent has sent home some particulars from which we extract information, but demur to many inferences derived therefrom:—"Previous to 1870 102,000,000 dols. was invested in the iron trade, and since then, to meet the demand for iron required by the rapid extension of railroads, there has been at least 50 millions more added

to it. In 1876 there was 714 blast furnaces in the United States, capable of producing over five millions tons of pig iron annually, but as the actual production for that year was only 2,093,236 tons, it must be assumed that more than one-half the capital invested in them has been wasted. There were also 332 rolling mills, which produced 1,921,730 tons of roller iron and rails; but their capacity is over four million tons. Besides Bloomaries Catalan forges, open hearth furnaces, and steel works, there are 11 Bessemer rail mills located from Troy to St. Louis, which made 412,461 tons of rails. Twenty-three States and the territory of Utah made pig iron in 1876, of which 990,009 tons were smelted with bituminous coal and coke, 749,578 with anthracite coal, and 308,649 tons with charcoal. Pennsylvania made almost one-half of the total product, next to which Ohio, New York, Kentucky, West Virginia, Illinois, and Missouri are iron-producing States; but, as compared with 1873, the year of greatest production, there has been a decrease equal to 27 per cent. in the total product of last year. The entire decline has been in the anthracite coal region, from which it would appear that competition is driving the iron trade into the bituminous districts, where coals and ores are cheaper and more convenient for each other. The annual production of ore from the mines of the United States is over 4,500,000 tons, of which more than two million tons of clay, ironstone, and brown and red fossiliferous ores is raised in various States. Over one million tons is taken out of the mines of Lake Superior, and above a quarter of a million tons is mined in the iron mountain district of Missouri; while the chief part of the ores required for the furnaces in the northern and eastern States is brought from the mines of Lake Champlain and New Jersey, and from the great deposit in Pennsylvania known as the Cornwall Banks. American ores are in the aggregate nearly twice as rich as the ores raised in Great Britain, and nearly one-third are fit to be used for Bessemer steel, while only one-eighth of the English are said to be fit for that purpose. Still, with those advantages the average price of pig-iron in 1873 was 42¾ dols. per ton, and steel rails 120½ dols.; and now, when labour is as cheap as it can be, and coals and coke are selling for less than 1 dol. 50 c. per ton, pig-iron sells for 16 dols. to 19 dols. per ton, and steel rails 42 dols., at which prices the ironmasters state they are losing money.

There has been a project before Congress for admitting the import of English iron, and the ironmasters say that would ruin them. Protection is causing more misery and loss than it has yielded profit, and will have to be abandoned. Great works have been erected under its reign, on money borrowed at 10 per cent.; and in places where the cost of carriage of ore is more than the English pig-iron. Companies and shares, prospectuses and falsehood, have made a condition of affairs that must be left to find its own level; but if these vanish, and monopolies cease, Americans say that iron can and will be made in various parts of the United States as cheap as in England when population and capital concentrate in those places. In a district of Southern Ohio, 100 miles square, iron and coal are found in the same mines. In many parts of West Virginia coal and ore are close together, and in Georgia and through the Black Warrior coal region of Alabama there are mountains of hematite ores very rich and easily mined, and carriage must be cheap, for the country is permeated with navigable rivers which run to the Gulf at Mobile. In Tennessee an English corporation has a coal and iron estate of over 150,000 acres, on which they have opened mines and are building iron works on a large scale, while at the Cornwall Banks, near Lebanon, the ore and limestone required to make a ton of pig-iron will scarcely cost 50 c. at the furnaces beside the mines, and 35 cwt. of anthracite coal from Schuylkill Haven, down grade, 85 miles, 4½ dols., to which add 2 dols. for labour at the furnaces and 1 dol. for freight to Philadelphia, and you have a total of 8 dols. for the cost, exclusive of the ironmasters' profit of producing and delivering at tide water a ton of pig-iron fit to make Bessemer steel. This great deposit of magnetic iron ore is about three-quarters of a mile long and 500 ft. broad. In some places it is 350 ft. above the level of the plain and from 50 ft. to 300 ft. beneath it. The ore is free from phosphorus, but sulphurous, and averages 50 per cent. iron, and one man can mine and load on the waggons from 10 tons to 12 tons per day. There are 64,000,000 tons of ore in sight, and geologists say the deposit is inexhaustible. Still the owners limit the annual production of ore to 200,000 tons, to enhance the price of iron. A part of the ore they smelt, but the bulk of it is sold to other furnace men at 2¼ dols. per ton, equal to 4½ dols. for the quantity required to make a ton of pig-iron. If this mine were in the hands of one of the great English ironmasters, it is not likely he would lock up the mineral or require a protective tariff to enable him to make iron and steel for the markets of the world, not excepting those of Great Britain. There are many fine iron works and furnaces in the United States, and the experience gained during the development of the iron trade in England enabled their projectors to adopt the most improved plans, plant, and equipment. In the Lehigh Valley there are 51 anthracite furnaces, several of them over 70 ft. high. At Pittsburgh and other places in the bituminous districts there are many large ironworks, perhaps the most important being the Cambria Iron and Bessemer Steel Works at Johnstown, which turn out over 80,000 tons of iron and steel rails a year. At Joliet and North Chicago, in Illinois, the iron and Bessemer steel rail works are also very extensive, and capable of producing 50,000 tons of iron rails and the same quantity of steel rails per annum; but I think the most complete works in the Union are those at Bethlehem, 50 miles from Philadelphia, which are under the superintendence of Mr John Fritz, the eminent mechanical engineer. The buildings, which are of stone and iron, are well designed and substantial, and the engines, hydraulic plant, furnaces, rollers, &c., are ingeniously improved. In connection with the steel rail mill there are two blast furnaces, each 70 ft. high, from which the smelted iron is conveyed before it cools to the converters. By this means and economy in the heating furnaces six tons of coal are saved on every ton of steel rails produced; but as a set off to this saving, the coals and ores are brought from a distance of 60 to 80 miles. The following are the general rates of wages in the Lehigh Valley, and now in force at the Bethlehem Iron and Steel Works:—Machinists, per day of ten hours, 1 dol. 40 c. to 1 dol. 80 c.; smiths, 1 dol. 60 c. to 2 dols.; moulders, 1 dol. 60 c. to 2 dols.; masons, 1 dol. 60 c. to 1 dol. 80 c.; carpenters, 1 dol. 40 c. to 1 dol. 80 c.; engineers, 1 dol. 30 c. to 1 dol. 60 c. The principal roll hands can earn up to 3 dols. 25 c. a day of twelve hours; boiling iron, 3 dols. 50 c. per ton; puddling iron, 3 dol. 25 c. per ton; furnace keepers, 1 dol. 50 c.; chargers and slagmen, 1 dol. 25 c.; and labourers, 80 c. to 90 c. per day. These rates of wages are fully cent. per cent. below the price of labour a few years since, and the same applies to the wages in every other branch of industry.

Workmen are adapting their mode of living to their diminished earnings, and employers realize the changed condition of trade. They are content with less profits, and are pushing an export trade. We in England must face this, for it is culpably foolish to live in a fool's paradise.

A Pottsville firm is making rails for Cuba, and a few weeks ago the Philadelphia and Reading Coal and Iron Company contracted to supply the rails, bridges, and other ironwork for 180 miles of railroad in Brazil. At the Baldwin Locomotive Works, Philadelphia, there are a large number of engines building for foreign countries, and one of the firm is now in Russia arranging for a large Government contract. For some years past certain descriptions of American manufactured goods have been largely sold in foreign countries, but since the close of the Centennial Exhibition orders have increased, and it is reliably stated that American labour-saving machinery, agricultural implements, hardware, cutlery, edge tools, axes, saws, &c., now meet with ready sale in Europe, South America, and Australia. There can be no doubt there is a growing preference for American goods in many foreign markets, and I believe it is chiefly because the Americans study the requirements, tastes, and habits of the peoples they manufacture for, as they are in the habit of doing for their home markets, because many of the States of this Union are as varied in climate, soil, and population as so many foreign countries, while many English manufacturers are content to work in the old groove, and consider the goods suitable for the British Isles and their peoples should answer the requirements of every country and of all mankind. It is astonishing in the face of hard times what rapid progress Americans have made in the manufacture of iron products. Perhaps the hard times stimulated their genius and industry, as they have reduced wages and diminished profits so that England might in future expect a sharp competition from them in many branches of her industries. Their products are well adapted for use, and they are improving in design and finish; and the American manufacturers, who are enterprising and inventive, adapt labour-saving machinery in an admirable manner to every branch of productive industry. Besides, their workshops and factories are recruited from the industrial centres of Great Britain and the European Continent, and the genius, skill, and experience of those peoples largely contribute to develop and build up American industries. Labour is also good and cheap, and possibly will continue to be cheap, especially in the sea-board States, where emigration will be constantly increasing the number of workmen. Therefore, if England is to maintain her industrial pre-eminence her people must note the progress of other nations, and the means by which they achieve it; and if, instead of seeking to revive Protection, which is, happily, long dead in England and is dying here, those manufacturers of Birmingham and Sheffield would travel, like

Americans, and see more of the world, they would learn from observation what articles of commerce were best suited to the climates and habits of different countries and peoples, and they would be more qualified to direct and utilize the labour of their workmen, whose skill has made those English towns famous; for as other countries possess resources at least equal to those of Great Britain, it is clear that its future prosperity will very much depend on the skill and intelligence of its population, and the wisdom with which it is directed."

A most valuable collection of statistics on the subject of Bessemer Steel has been issued privately, and will appear in the next annual report of the British Iron Trade Association. Our readers are acquainted with the history of that wonderful invention which brought the price of steel from £60 a-ton down to £12, and saved millions of tons of coal every year. Now that the royalty has ceased by effluxion of time, the price is much lower than that; and successive improvements introduced since the process was first given to the world, have resulted in making Bessemer steel almost absolutely as cheap, and relatively much cheaper than ordinary malleable iron. Hence has followed the decay and collapse of the finished iron trade, which has gone to the wall with startling rapidity during the last four years, involving, as a matter of course, the loss of a great deal of capital and the transfer of much more; the uncertainty, groping, and perplexity incidental to a new industry; the enforced idleness of thousands of workmen, and the creation of new avenues of employment for many more; and, finally, the ultimate economy of all undertakings in respect of which steel has come to be employed.

In this country, which is the cradle of the Bessemer steel trade, as it has been of nearly all other great metallurgical discoveries, the development of this industry has been more rapid during the last five years than during any previous period of equal duration, notwithstanding that this interval embraces such a prolonged and serious tide of adversity. In 1870 there were only 18 Bessemer steel works in Great Britain, having 85 converters, and the total production of ingots was 215,000 tons. Last year there were 24 Bessemer steel works in operation, having 110 converters, and producing about 750,000 tons. Hence the production had more than trebled within seven years. But these figures do not represent anything like the *maximum* capabilities of the Bessemer plant available for use. The full extent of these capabilities can only be gauged approximately. Bessemer converters, like blast furnaces, vary in their productiveness according to the treatment they receive. In 1876, according to the *Metallurgical Review* for December 1877, the average output of a pair of 5½ to 6 ton vessels in the United States was 225 to 250 tons of ingots per 24 hours, and Dr. Siemens was informed that at the North Chicago Steel Works as many as 73 blows had been obtained in one pit in 24 hours. ("Journal of Iron and Steel Institute," No. 1, 1877.) But in this country 180 tons per 24 hours from a pair of 7-ton vessels is considered a good yield, and in Germany the average yield of each converter in use did not exceed 6,728 tons per annum—a discrepancy which Dr. Wedding ascribes entirely to the superior mechanical appliances of the American steel makers (*Reichsanzeiger* for October 1876). If, however, we assume that each Bessemer converter in the United Kingdom is only capable of yielding 90 tons per 24 hours, we should have a production of 27,000 tons per converter for 300 working days; and on this average the Bessemer plant already constructed in the United Kingdom should be equal to furnishing 2,970,000 tons of steel ingots per annum—a production equal to that of the whole world at the present time.

On the face of it these figures would indicate that our productive resources have gone far ahead of the demand for Bessemer steel. England is not the steel maker of the world in the sense that she was, until a few years ago, the world's iron maker. We supplied iron to every country in Christendom, because we had learnt before other countries, how to turn to commercial account the resources with which nature had so liberally endowed us. But before the steel era had been fairly introduced other nations had become alive to the importance of supplying their own wants instead of trusting to another, and hence the fact that England's development of the steel trade has proceeded pretty much on all fours with the competitive development of other countries. We have even lost ground relatively, although not absolutely, in the race of development, for the United States have increased their production of Bessemer steel ingots between 1870 and 1871 from 40,000 to 525,996 tons; while England has only gone from 215,000 to 750,000 tons. Nor is this all. Americans, somehow, get a much better return for the capital invested in Bessemer works than their English competitors. There are only 27 Bessemer converters in the whole of the United States, and yet they produce within 225,000 tons of the yield got in England from 110. The output of Bessemer steel ingots in America during 1877 is believed to have been much larger than in 1876. Her own requirements will supply America with a constantly increasing demand for steel rails. There are now in that country about 80,000 miles of railway. Much of this mileage is single track, but, in the long run, no doubt it will be doubled and supplied with as heavy metals as are used in our country. To lay the present railroads of America with a double track of rails weighing 70 lb. to the yard would require between 15,000,000 and 18,000,000 tons of steel rails, representing at present prices a capital of 126,000,000. dols. These 18,000,000 tons of rails would require renewal from time to time—for the longest lived-rail must give way at last—to say nothing of the new mileage that must be opened out in the natural order of things, so that the American steel rail trade may be regarded as pretty safe; and those who have it in hand appear fully determined to exclude, if possible, the competition of this country. But it is not America alone that now offers a rival front. Germany is producing 242,261 tons of Bessemer ingots per annum; France, 261,874 tons; Belgium, 71,758 tons; Sweden, 22,789 tons; and even Russia is now entering the field with an annual production of 8,500 tons. In Europe and America together there are now 85 Bessemer steel works, with 297 converters, capable of producing, if used in conjunction with the most recent appliances, not less than 7,000,000 tons of steel per annum, or fully three times the quantity actually yielded at the present time.

Although thus obviously suffering from the stagnation that is common to all industries, and most of all to our metallic trades, at the present time, there is a general *consensus* of opinion that steel is the metal of the future, and that our dependence must more and more be placed upon this product. Much has been done within the last few years to cheapen the cost of production, so that steel rails at works in Sheffield or Wales cost now within 12s. per ton of iron rails in Cleveland. So much yet remains to be done in this direction that it need excite no surprise should steel rails be ultimately brought quite on a level with iron. But iron seems to be even already doomed. The craft of the puddler and the cunning of the artificer in iron will be more and more at a discount. Some authorities, indeed, have pronounced puddling to be a thing of the past. This, perhaps, is going too far, but it is travelling, nevertheless, in the true direction. With due allowances for certain kinds of merchant iron peculiar to the Staffordshire district, steel will undoubtedly displace iron in the long run. It has done so already for railway purposes. It is fast nearing that point when it will likewise eclipse iron for shipbuilding. The recognition now given to steel for naval construction both by the Board of Trade and Lloyd's Registry will enable it to complete with iron, not only on equal but on better terms, and contracts for the building of both war and merchant vessels are now executed at several of our ports.

MARBLE PAPER—HISTORY AND MANUFACTURE.

VERY few of general readers and workers possess any knowledge of the manufacture of a production of great beauty and infinite variety that graces every description of book, and will yet be developed in the range of ornament that adorns and distinguishes our own age. The so-called marbled-edges, and the so-called marbled paper make an art that is unique among the decorative arts, and perhaps a little disclosure of the practice thereof may be as useful as any other subject in the supply of information, and in the promulgation of art enthusiasm.

Some five-and-twenty years ago the manager of a Patent Marbled Cloth Manufactory—Mr. Woolnough—wrote a little book on the subject; and so much may be said of Mr. Hannett, whose chapter in Bibliopegia is a fine help to a worker. We have now a paper on the Art of Marbling from another Mr. Woolnough, and from the combined materials there is a chance of making plain what is really marvellously simple, and in a department of knowledge that is seldom remembered.

In 1731 a government grant for fourteen years was made to Samuel Pope for "a new art for marbling paper with a margent, never practised by any person whatsoever before he invented it, which is performed by a method entirely new, by taking off the colours from a body of water prepared after a particular manner, with a proper strength for supporting the said colours, and make them flow upon the surface of it, whereby the said colours are more easily taken off upon paper; which will be of very great service to the publick by preventing counterfeits of many kinds."

Then in 1762 Mr. Houseman revealed his secret thoughts on

the method of marbling paper: he took of gum tragagant (by which he must mean gum tragacanth or adragant, that exodus from *Astragulus verus*, a tree growing in America and the north of Persia) three or four pounds, and of alum about half a-pound, and put them into hot water; let them stand twelve hours, then mix them with cold water till of a thickish consistency; then take of cooged lack (a kind of shillac which would give polish) three or four pounds, made fine and ground with water and any kind of spirits; of indigo about a quarter of a pound; of chalk about five pounds, mixed together; of orange opeate about one pound; of aurum-pigmentum about one pound, all made fine and ground with water; the preparation of tragagant and alum to be put into a square trough the size of the paper. Make the colours all thin with water and a little spirits, and put them upon the preparation of tragagant and alum in the trough with woollen mops, to which put about five spoonfuls of gall, or any other quantity, until the colours spread themselves upon the tragagant and alum. The pattern is formed according to fancy, upon the preparation of tragagant and alum, with a wooden pin and a wired comb drawn over the colours when dry, glaze with a flint stone made smooth for the purpose.

This old invention is not old enough. The process must be of the remotest antiquity, common to Persia, and other nations a thousand years ago. Linseed makes a good float, and a baking dish a good trough; while for skill no intelligent lad can fail to produce amusing and satisfactory results. We will show the way as having practical acquaintance therewith.

The marbling of edges and of sheets of paper requires care. The preparation of every article used must be properly done. If any part is faulty all goes wrong. There must be a shallow trough of the size of the sheets to be marbled, or the length of the books whose edges are to be dipped; this trough must be water-tight. Besides there is required a round stick of the size of a round carpenter's pencil, and cups containing the prepared colours, arranged in a proper manner, with their little brushes or bundles of bristles; and of course there is also a marble slab and a grinding muller to prepare the colours.

The trough may for amateur purposes be improvised from an ordinary tin baking dish, about an inch or an inch-and-a-half in depth, into which the size is poured when prepared. The proper method of making size is to take a quantity of linseed and put it in a basin, pouring over it boiling water and keeping it well stirred. This will yield a mucilaginous body that, when transferred to the baking dish, will be of sufficient gravity to bear the colouring matters of which the work is made. The proper consistency must be ascertained by experience, and its adjustment either by water or seed is very simple and easy. The best plan is to make the first quantity too thick, for the adding of seed is often unsuccessful because the body gets gradually too thick, whereas if the first is too thick it is readily reduced to a permanent consistency.

There are three marbles familiar to all book people, respectively designated as Shell, Spanish, and Dutch; the first is the most ancient and always in favour; the second is smarter, having a shaded diagonal pattern in addition to common marbling; the third is that used for the edge of account books, and for lining the covers of historical books or ancient literature.

In prescribing linseed we are quite aware that many other sizes are used, and by some preferred. Our work has always been done on linseed size, made of half-pint of seed to four or five quarts of boiling water. The old patent (gum-tragacanth) is still used, but chiefly as a mixture. It is commonly known as gum-dragon, and must be selected with great care, for the defective qualities spoil all the work: the pattern runs away, or is lumpy and ill-looking. If gum-dragon is used, the best treatment is to put a pound of it into a glazed vessel that will contain half-a-dozen gallons of water. Begin by pouring on two gallons of soft water, stirring it well with a bundle of birch twigs, and adding water gradually until enough is manufactured and of the just consistency. It will dissolve in about three days, and then be strained off into the trough before mentioned.

For Spanish Marbles, that is, the diagonal shade across the patterns, what is known as flea seed is employed, because of its being much stronger than linseed or gum-dragon, and by mixing with those gives them the property of bearing the pattern upon the surface to a much greater perfection and length of time. Colours are very apt to sink, and this is an important consideration in the general operations. The proportions for its making are;—two oz. seed to two quarts of boiling water, well stirred for a quarter of an hour, and then left to settle: add more water and more stirring after an hour's time, which practice is repeated until the seed is ultimately at the bottom of the vessel, and the size is clear.

But ox-gall is the most essential factor in the art of marbling. It is nasty stuff, but it is none the worse for all that. You may keep it until it is offensive, but it retains all the properties that marbling demands. I bought an ox-gall from our neighbouring butcher when living in the country, and engaged in book-binding,—bladder gall straight from the slaughter-house. Now it is important to be careful in the use of ox-gall. If it is desired to produce the Shell Pattern with a few veins of different colours, say blue, red, or yellow ochre, ox-gall and water in the proportion of one to six will have to be applied to the vein-colours,—say Blue, Red, or Yellow, and very carefully must they be mixed, little by little, stir and stir quietly until a result is attained that in practice suffices. The ox-gall is necessary to make the colours float: if they go down, more gall is required: if they fly all about as if frantic, less must be employed; or, which is the same, more of the reserved colour should be added. The application of water, gall, and colour is an art that never can be prescribed; it depends on intelligent observation and experience.

But the final colour—say brown or grey—must not have so much gall. The first—blue, red, and yellow—having been thrown down from the spattering brushes upon the linseed surface, the body colour that has to cover the ground whereon the contest of colours has been fought, and every one driving the other about, until the vein-like result is attained, the last has to fill up the blank space, and throw up a characteristic result—that shall remind the observer of the geological strata from whence its name is acquired, and yet preserve the veins in something like natural order.

This final colour must contain another ingredient,—oil. Some use olive oil; our habit happened to be the painters' boiled oil. This ingredient produces that ring or form reminding one of fossils embedded, which is famous to every observer of marbled paper. The last colour must be also slightly thicker, because by being thicker it does not fly about too much, and the gall and oil impart light and shade to the fossil-like drops as they spread or cover one another. Gall gives fineness to the veins, and oil concentrates in a manner that fills up the pattern.

It is perhaps necessary here to observe that the colour-mixing is a most important business. Bees-wax of the very finest quality must be obtained, and cut up into the smallest pieces, and then put on the hob to melt: as it melts turpentine should gradually be added, until the mass has the consistency of honey. Then in selecting the colour material it is better to avoid mineral colours as much as possible, because they sink to the bottom of the size. Of vegetable colours and ochres, there are Indigo and Prussian Blue, mixed with Whiting for lighter shades; Dutch Pink, King's Yellow, and Yellow Ochre; Brown Umber, burnt; Vermillion or Oxford Ochre, burnt; Rose Pink or Lake, and the various compound colours, such as Green, Orange or Purple, produced by mixing the former. This bees-wax-and-turpentine prepares the work for taking the polish, and also gives permanency and richness.

When all these items are duly and properly prepared and arranged, it is better to take a sheet of waste paper, and lay it on the surface of the linseed or gum in the trough, to take away what scum may have accrued. Then quickly take up the little bundles of bristles or brushes from the colour cups, and sprinkle them over the area, one after the other by striking the brush or bundle on a stick or the left hand: the bright colour first, then the brighter, and then a darker—these drive each other. Then apply the heavy one—say brown,—or whatever is desired to become the ruling colour. The first three fly into veins, and the last fills up the whole area. The operator then takes up a sheet of paper, and carefully lets it down from the end of the trough, until all is laid so as to drive out bubbles and air, and then the sheet is raised, and the pattern that was upon the gum or linseed is transferred to paper, which is called marbled paper. Of this we will speak more particularly hereafter. Let us here set out the way of making the colours. It is information that may be useful in many other ways than in the making of marbled paper or the marbling of edges.

They should be bought in the dry stalk just as they are produced, or manufactured either in lump or in powder, and it is better to have a marble slab and muller, and grind them at home. Everything depends upon the perfection of the grinding when mineral colours are used, or where vegetable colours are manufactured in connection with earth. For Blue, the best recipes give,—2 oz. best Indigo, finely powered, mixed with a teaspoonful of Spirit of Salts, and 2 oz. best Oil of Vitriol—sulphuric acid. These are put into a bottle, and that is placed in boiling water for six or eight hours; it is then ready for use. It is the most useful of all colours, for if a lighter shade be required it will take up China Clay, or, if the same colour, only less strong, it bears dilution with water. Prussian Blue does not work well, being too earthy the burnisher smears the work by scattering the particles over the other colours. Ultramarine is almost too costly for the marbler's purpose, and is very tiresome in working from its want of adhesion. There are some lower qualities, produced chiefly in Germany, that are extensively used for colour-

making and for paper making, but Indigo, when of best quality, is the favourite.

Browns are made in two ways ; we prefer the former. Take of Turkey Umber, and burn it on a piece of tin over the fire, and afterwards grind with rain water ; or, take 4 oz. of logwood and 4 oz. of French-berries—boil them together. If a darker shade is desired, add a little copperas.

Reds are of various materials. Half-a-pound of Brazil-dust, an ounce of French-berries bruised, and a little alum boiled in rain water and strained, is a very good old method. There is a Lake manufactured at Birmingham that is a favourite with marblers ; this colour is sold in a damp state, and may be mixed and even used without grinding, and is made almost exclusively for marblers. Deep Lake is at once the most beautiful and costly of the reds. There are three shades of this colour, viz.,—Scarlet, Crimson, or Purple, the first of these possesses a brilliancy which no other can produce ; but great care must be exercised in its selection, because there are many worthless imitations in the market. The test in selection is : take a piece and put it to the tongue, and if it adheres the sample is bad, if it absorbs without adhesion, the chances are favourable. Vermilion is much too heavy, and is seldom employed except for antiques, because of the difficulty of floating so weighty a substance. Logwood chips, in the proportion of half-a-pound to 2 ounces of alum, and a small piece of copperas, boiled in three half-pints of soft water until reduced a third, makes a good purple ; other makers prefer making this colour, which is seldom required, by mixing blue and red according to the desired shade. Olive is made by mixing Indigo with Burnt Ochre, and Green is best made by combining Indigo with Yellows such as Dutch Pink, which is a preparation of Quercitron Bark, and a preparation of Whiting. This Dutch Pink is a capital aid in the composition of many yellow shades ; for instance, White Chrome, which is, when good, a remarkably fine yellow that in itself varies from a light lemon colour to a deep orange, and is tiresome to work by itself, although, when combined with Dutch Pink, it becomes tractable enough. But make Yellows of French berries, saffron, or faustic chips, which are boiled with a little alum, and then strained and put away.

There is this advantage in decocted colours, they can be prepared and put aside for an indefinite period, which, in remote country places where bookbinders have little to do, and amateurs only practise for amusement, is a consideration when compared with the half-day's preparation necessary where the colours have to be ground. Foreign manufacturers use chemical colours in preference to the minerals ; and their variety of production, both in style and pattern, is illimitable.

The old familiar marbled paper is called the Shell, from its having some resemblance to the surface exposed by cutting a block of fossil shells in two. This pattern has generally a brown ground, but any colour will do. When good paper is used and care taken, the effect produced is as elegant and beautiful as any other style can exhibit. Mr. Hannett's manipulation is one we have used with perfect success. Put a little of each of the colours you wish to use, properly prepared, into separate cups and add thereto a small portion of *ox-gall* and water, mixing them well up with the brush appropriated to each colour. This will be all that is necessary for the vein colours, which are those thrown on to the size first. To the upper ones, the dominant, which drive the former into veins—say red and yellow and perhaps blue—the brown which is to form the shell, add two or three drops of boiled linseed oil, and mix well with the brush, so that it is thoroughly incorporated with the colour.

The size must then be poured very carefully into the marbling trough, taking care that if linseed no seeds run in, or if gum-dragon no dirty matter, and then it is better to make an experiment in order to ascertain whether all is in good condition. Sometimes this experiment is made in a saucer, because, if any part of the preparations is defective, the evil may be detected without spoiling the whole volume of size. A small portion of the colour is taken in the brushes in the order it is desired to use them on the size, by gently tapping against the fore-finger of the left hand. If they do not spread sufficiently more gall must be added ; if otherwise, more unmixed colour. The same must be done with the upper colours, as respects the oil ; if on trial the shell should not be sufficiently developed, more oil must be employed ; if, the contrary, the oil causes white spots or breaks, more colour must be added. The oil produces the shell pattern, every drop resembling a fossil, and the little drops falling on the larger resemble a tiny shell embedded in a larger. Oil is a delicate thing ; if too much is employed we could find scarcely any relief in adding more colour, the oil could not be attracted from its early home sufficiently to admit the new colour to an equal share, and of course the work was rendered imperfect ; generally that colour must be thrown away and a new cupful made up.

When the colours are made to act properly, there should be rapid action in the working. Throw on the first carefully, and it spreads all over the trough, and is almost imperceptible, resembling a thin scum ; follow with the second, and that will crowd the first together by spreading itself as far as possible on the top of the other, and driving it away ; the third does likewise ; then throw on the one containing the oil, and instantly the vein is created, the red blue and yellow huddle together in thin lines, crowding up the interstices left by the brown, which becomes the ruling colour. If paper is to be made, the white sheet is taken up lightly, and the right hand end is permitted to drop on to the size, and the whole sheet is carefully and gradually lowered in a way that allows the floating air to escape, and there is the pattern complete. Book edges are marbled precisely in the same manner. The several volumes are held firmly together with a cutting board, or any piece of wood, on each side, and the whole block is dipped in to the depth of a quarter of an inch, the right end first as before stated to admit the escape of air, and then when it was withdrawn there are commonly bubbles that the worker blows off, and gives the mass a shake, to throw off the superfluous size, leaving it tied up until dry.

Some vein papers have the body colour much broken up, as if the fossil had been pulverized and mixed with chalk before being put in its position. This curious effect is produced by a drop or two of turpentine being applied to the last colour. The marbled-paper-hanging manufacturer uses the same ingredient to make that beautiful broccadillo pattern resembling a strata of pulverised chaotic matter, with, in his case, angular forms such as might come by breaking glass into small pieces.

Old books and especially folios use a spiral pattern, each circle being perhaps two inches in diameter. It is a grand style, and when well wrought has a rich antique effect.

In the preparation of colours therein employed, spirits of wine is used and no oil. With the pointed stick the colours are touched and dexterously put in motion in volutes, by turning them at such distances as may be required. But, if like the well-known Dutch the effect is to be of the style—only much more varied in every way, form, colour, and quality,—of account book marbling, it is necessary to lay the colours on the size in stripes by means of a quill charged with the fluid colour, then with a properly made comb which the worker draws from right to left first and then from left to right, which produces that ridge-like form seen in antique books especially, and much used in the modern developments of antique binding. The same process is employed in a diminutive form producing the pattern generally used in pocket memorandum books. This jagged style is susceptible of great variety.

There is a singular pattern produced by the comb-and-rake agency which we regret, like as with the others, we cannot give in specimen. The reader will imagine the effect when we say the comb goes backward and forward, just as in those now named, but a rake is drawn transversely backward and forward, producing a most extraordinary jumble, as if the other had been violently dislocated.

The Spanish marble is of the same colours, and its making is conducted in the same manner as the common. The diagonal effect is the only difference. The pattern is made diagonal, and the forms are more or less oval ; added to which there is a shading between the lines. The effect produced is in the application of the book edge or sheet of paper to the floating pattern. The trough must be much larger to allow space for the operation which is :—to lay down one corner of the paper first, at, say an inch in width, then drag it half-an-inch and drop it a little further on, drag that and again drop, and so on ; this gives double intensity to the part twice dipped, and being wet and strong produces an artificial shading besides elongating the pattern.

Now, an amateur can execute marbling upon these instructions. The writer has done so, and it is a very pleasant occupation, and a useful one. Country binders in old days, would practise it once in three months, or more frequently, if a sufficient number of volumes could be put aside to make a day's work ; but in London and large towns, garrets and kitchens have occupants who obtain a humble livelihood by book-edge marbling. But the importance of being particular can never be too much insisted upon. Hard water, bad gall, careless grinding, ill chosen materials for colours, size too thin or thick, may disappoint, as many have been disappointed, and spoil all the preparations for a day's pleasurable employment. The art is of the simplest, and needs really no teacher, and, moreover, it enlarges one's acquaintance with many cognate matters, and is of use also.

Of the origin of marbling patterns many stories are current in the trade. For the most part every variety has been the result of accident or experiments made for amusement. One that had

a good run some thirty years ago and has now, is said by Mr. Woolnough in his book (1853), to have been produced thus :—A man in his workshop was proceeding with his work, had put on all his colours, and was just commencing the process of laying on the sheet of paper, when just as the corner touched the liquid, another came and drove violently against the trough, by which the surface of the solution with the colours then floating upon it was instantly put in motion like the waves of the sea, and the effect thereby produced excited further study and research that led to the production of Spanish Marble. He adds another, but all are the common incidents of every workshop or even laboratory.

The chemistry of marbling is better understood abroad; but our English houses persistently adhere to the old ways. Hence the superiority the foreigner has in neatness, minutiæ, and the immense variety of colour. It would appear too that in burnishing they excel, especially in their good qualities. In England there is a custom of subsequent sizing in order to attain a higher polish than the burnisher over the first gum-and-colour can produce, and also in order to fix the colours; but we are persuaded from experience and observation, that much can yet be done to improve the art and manufacture of marble paper, which, in Germany, is conducted at establishments very far beyond any thing in England, for these patterns are not made there by hundreds, but by thousands.

TECHNICAL EDUCATION.

AN example must result from the experiment which the Master of the Coach-makers' Company has set, in offering prizes to be competed for by members of the Drawing and Technical Class for Artizans in the Coach-trade of London, held at the Working Men's Club in George Street, Grosvenor Square, London. The contention about this matter is in the possibility of arranging such conditions as shall give the inventor a prospective share in the profits of his invention, as well as a prize for the thing itself. Most of the improvements in construction are the products of the artizan's brain, and ought to be as profitable to their orginator as to the capitalist. But they are not. Artisans have hundreds of ideas that are unknown to the market; and they keep them, because, as they fearlessly say, the reward that is probable is really insufficient : the master gives a *douceur*, and then makes a prodigious profit in which the workman has no share, out of a future that ought to be a provision for both. One cannot feel that such a view is unjust : and it will force itself on the attention of the public when the Patent-Laws come under discussion. Could not an addition be made to the list of items below in an article that says : "If the model accepted is put into practice, the inventor shall have a royalty for seven years," or alter the 5th clause, which exposes the drawings to the public, into one that shall not allow the public to be in a position, by mere eyesight, to deprive the intelligent workman of his reward. If drawings are exposed the idea is published. There should be a protective clause, if only to allay the disagreeable suspicion that now evidently is existing.

The following prizes and conditions are offered by Mr. Saunderson, for competition among members of the Drawing and Technical Class for Artisans in the Coach-trade of London, held at the Working Men's Club, George Street, Grosvenor Square :—First prize (for novelty in the design of a carriage), £8; second, £5; third, £3.

1. The design may be on paper or card board, or may be a model; if, however, a model be chosen for the first, second, or third prize, a further sum of £5 may be awarded to compensate the prize winner for extra time in preparing a model.

2. Each competitor must send a satisfactory certificate that the work is entirely his own.

3. The designs, or models must be sent to the secretary on or before May 1st, 1878, each bearing a distinctive mark or motto, accompanied by a sealed envelope bearing a similar mark outside, and containing the name and address of the competitor inside. These envelopes will not be opened until the judges have made their awards.

4. Drawings must be sent in sets of three, showing the side, back, or front, and the plan of the design, on not less than an inch scale.

5. The drawings and models will remain the property of the competitor, but may be retained a few weeks for public exhibition.

6. The judges will be nominated by the committee of the class.

7. The carriage, or parts of a carriage, designed or modelled, may be close or open; the novelty may be in shape or construction, or in improved fittings to open the head, or some similar improvement; or in an improved application of a brake retarder, or in carriage springs; or in a more simple and economic method of construction, always bearing in mind that each novelty should be calculated to render carriages more perfect, and to promote the sale of carriages to purchasers, and thus to benefit the whole trade, by creating a greater demand in this and foreign countries.

8. The committee reserve the power of withholding the prizes if none of the works sent have sufficient merit.

Mr. G. A. Thrupp, is the secretary (Thrupp & Maberby), 269, Oxford-street.

Chemistry applied to the Arts, Manufactures, etc.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

Phosphorence.—If some sulphate of quinine is strewn over a sheet of smooth paper and exposed to a heat of from 120 to 140 deg. Fah., by means of a plate of metal, the *Scientific American* says, it becomes phosphorescent when stirred with a glass rod. Valerate of quinine exhibits the same phenomenon without heat being applied, if the crystals are rubbed in a mortar. It is said that the appearance is only noticed when the valerate contains an acid prepared directly from the root of valerian.

Fire-Proof Flooring.—An English brewer has made his malt floor of three-inch planks grooved together. A fire broke out, the roof over the floor fell in, and the fire raged for nearly four hours over the floor without burning through it, because the grooves prevented a supply of air from below. This security might be increased by covering the beams and the under side of the planking with fire-proof cement.

Removal of Grease from Feed-Water.—M. Hetet uses lime water to fix the fatty acids in the feed water of boilers in engines with surface condensers. The corrosive action of such acid rapidly wears into the boilers, and the greasy water cannot be made porable by distillation. M. Hetet's method has been introduced in many vessels of the French navy, and he claims that it adds greatly to the duration of the boilers, while it furnishes a distilled water without odour or taste and unobjectionable for corking or for drinking.—*Comptus Rendus.*

Apparatus for Measuring Iron-Work.—In the *Annales des Ponts et Chaussées* for October last, M. Dupuy describes some new apparatus for the direct measurement of iron-work as much needed from the increasing number of iron bridges under construction. His idea is based on the fact that a bar of iron, that is one metre in length, stretches or shortens to the extent of one tenth of a millimetre or tension or compression of two kilogrammes per square mile of section. The apparatus requires to be used with great care, and should only be put in the hands of conscientious and intelligent persons; it is then likely to be of great service. The reported experiments vary the theory, and the theoretical maxima are said to be perfect.

Experiments upon Homogeneous Iron.—From late experiments in the dockyard of Castellamere the following inferences are drawn : 1. That punching alters the molecular constitution of homogeneous iron. 2. That this alteration does not extend more than a millimetere from the hole. 3. That annealing is of no use if it is employed before punching, but it restores the ductility if employed afterwards. 4. That this advantage is lost if the holes are subsequently enlarged by a reamer. Experiments with small punches are contemplated, having a diameter at least 2 mm. smaller than the holes, and the holes to be subsequently enlarged by drills.—*Il Politecnico*, from *Rivista Maritama.*

India-Rubber Piston Packing.—In the "Grands-Maker's" Coal-mine, Belgium, there is a cistern with a direct action pump that raises water to a height of 220 meters. The pump body was lined with metal, and the piston packed with steel rings. The effective work sank in a few months from 80 to 25 per. cent. An examination showed that the steel rings, on

account of the impurities of the water, had torn the lining and broken much of the packing. It was therefore decided to use a softer packing, and copper was tried with similar results. Rings of moderately hard caoutchouc, alternating with copper discs, were then substituted, netting 85 per cent. avoiding the wear of lining, and the consequent diminution of efficiency.

Strength of Iron at Different Temperatures.—G. Gesati and G. Saporito-Rieca find that the strength of iron at different temperatures shows peculiar irregularities. The strength in a wire that is exposed to a dull heat diminishes with the increase of temperature from 14° to 50°, then increases to 90°, diminishes rapidly to 120°, remains constant to 200°, sinks slowly to 235°; then comes a sudden increase which is followed by a gradual diminution. The strength is greater at 300° than at 140°.—*Pogg. Ann: Dingler's Journal*, 225, 512.

Wood Engravings and Photography.—The method of transferring by photography drawings, or sketches, to wood blocks for the purpose of engraving has long been known and practised, although attended by technical difficulties which have occupied the attention of scientific minds with a view to their removal. The chemical preparations in use have produced a surface too hard and brittle for engraving purposes. We believe the most perfect process is the "Hentschell," now being introduced by Mr. John Swain. The value of a method for securing exact replicas of old prints or engravings, or of original drawings direct from the hand of the artist, needs no comment. In this case the grain or surface of the wood is hardened and prepared for the graver by the processes employed to fix the picture.

Lighting by Magneto-Electricity.—The new mode of lighting by magneto-electricity was introduced at the Hanley skating rink, last week, with great sucess. The magnet is turned by a small steam engine of 3-horse power, and making from 800 to 1900 revolutions per minute. The current which produces the light is direct, no induction coils being used. The current is conveyed to the middle of the rink by a cable, which, in addition to conveying the electricity, also suspends a lamp, which can be raised or lowered by means of a windlass. The carbon points are regulated by the electric current in such a way that, as they burn away, they are kept constantly in a proper position to maintain the light. Up to the present time a number of lime lights have been used during part of the performances, but with the electric light in action the lime lights are quite insignificant, and when the gas jets were lighted the flames threw a distinct shadow on the sides of the rink. The light will be continued as a permanent substitute for gas, and the proprietors of the rink believe it will be cheaper.

Magnetism in Nickel.—The magnetic properties of pure nickel have been recently investigated by M. Wild, of St. Petersburg, who procured a nickel magnet in the form of a flat pointed bar, made by Wharton, in Philadelphia. The results are (1), Pure nickel takes as compared with the behaviour of pure soft iron, a considerable quantity of permanent magnetism; but the maximum of this is only half to a third of the permanent magnetism which may be acquired by a hard steel. (2), The magnetism remaining in nickel after cessation of the magnetising force is less permanent than in well hardened steel; the gradual loss of magnetism in course of time, both in warming and cooling, is in nickel greater than in hard steel, even when, by repeated heating and cooling, it has, like steel, been brought to a certain state of permanence. (3), The temperature coefficient of nickel magnets in the latter state is less than that of well-hardened steel. (4), The temporary magnetism which pure nickel acquires is about double its permanent magnetic moment, half of the temporary magnetism which hard steel can acquire, and a fourth of that which soft iron can acquire. In its magnetic behaviour nickel is thus throughout subordinate to steel and iron.—*Scientific American.*

Steam on the Paris Tramways.—The French authorities are encouraging the development of steam traction to the utmost, with a view to the forthcoming Exhibition. Last Sunday a formidable rival to Messrs. Merryweather put in an appearance in Paris, and ran very successfully with two carriages—containing 112 passengers—from Courbvoie to the Arc de Triomphe. The steepest grade was 1 in 48, and the speed maintained about seven miles an hour. The engine is very well made, hails from Geneva, and is said to be the design of an English engineer named Brown. We were much surprised, however, to find that the working pressure was fourteen atmospheres, a fact to which, probably, the passengers would greatly object were they aware of it; the motion is well raised from the ground, which is an advantage, but the method adopted is not mechanical. The weight is about six tons, the cylinders are 6 in., the stroke 12 in., the boiler vertical, with a horizontal annexe, and neither the fire nor water requires attention during a six mile run. Condensation is not attempted.

Arsenical Residues of Analine Colour Manufacture.—A process for rendering the arsenical residues of the manufacture of analine colours innocuous is announced by M. C. Winkler. The conversion of analine into fuchsine is best accomplished by heating it with arsenic acid, for five to eight hours to 182°. The residue, after distillation, is treated with boiling water and filtered; common salt is then added, whereby the rosanaline arsenate is converted into hydrochloride, sodium arsenate being formed. The fuchsine crystallizes out, leaving sodium arsenate in solution. The process for recovering the arsenic existing in the mother-liquor as sodium arsenate is as follows:—The mother-liquor is exactly neutralized with soda, and the colouring matter which separates is collected and sold as an inferior quality; excess of soda is then added till the liquid has a strong alkaline reaction. It is then evaporated till a pellicle forms on the surface, and poured over a mixture of limestone, and coal-dust, 30 kilogrammes of powdered limestone, and 25 of coal-dust being used for every 100 kilos. of a saturated solution of sodium arsenate. The mixture is stirred till it has become solid, owing to the crystallization of the sodium arsenate. This salt, when heated alone, is non-volatile; with carbon, and lime, all the arsenic is volatilized. The mass is heated in a reverberatory furnace provided with two soles, one above the other. The lower one should be heated to moderate redness, while the upper one has a temperature of some hundred degrees. The mixture of sodium arsenate, lime, and coal is placed in charges of 500 kilogrammes at a time in the upper sole to dry. The partition between the two portions of the furnace, is then opened, and the dry mixture allowed to fall on to the lower sole. The air must then be nearly excluded, so as not to burn the coal intended to reduce the arsenate. The arsenic may then be obtained either as metal, or as oxide. If it is wished in the metallic form, the vapours are conducted into a large chamber and condensed. It is advisable to have two chambers, to be used alternately. The gas which issues from the chamber, although it contains but a small trace of arsenic, has nevertheless a very disagreeable smell, owing probably to the presence of compounds resembling cacodyl, and should be led into a furnace and burned, to convert the arsenic into arsenious oxide, which, as it is present in so small a quantity, has no smell. If coke be substituted for coal, this disagreeable smell is to a large extent avoided. If it is desired to recover the arsenic as arsenious oxide, air must be allowed to come in contact with the vapour on its exit from the muffle. The arsenic burns, and the arsenious oxide is condensed in flues of the usual construction. By this process 2,500 kilogrammes may be worked in twenty-four hours, equal to 800 kilos. of arsenic acid. The residue consists of calcium and sodium carbonates. It is lixiviated with water, and filtered by the systematic method of filtration adopted in the soda-water manufacture, and the strong solution is used to neutralize a fresh quantity of fuchsine, mother-liquor. The limestone may be dried and used again, but it is advisable to throw it away for some time, as it becomes full of coal-ash. The recovery of 800 kilos. of white arsenic costs £1 2s. 6d. while its market price is about £10. This process has been adopted in many works, and has proved very successful.—*Journal Chemical Science.*